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Selection of elite silkworm (*Bombyx mori* L.) germplasm through rank correlation analysis

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ABSTRACT: The Spearman's rank correlation coefficient among 8 quantitative traits with 4 morphological parameters of 56 multivoltine silkworm germplasm was estimated. ANOVA reveals significant variability on economic traits among the accessions studied. The significant positive correlation was observed between numeric and non-numeric parameters. The five quantitative traits having positive correlation with cocoon colour and cocoon shape were subjected to score the index value based on evaluation index method and 10 top ranked elite silkworm germplasm were selected as best parental materials. © 2003 Association for Advancement of Entomology

KEYWORDS: Spearman's rank correlation, evaluation index, multivoltine silkworm races

INTRODUCTION

The hereditary traits studied in *Bombyx mori* L. accounts to 211, the second largest number of such traits studied among insects next to that of Drosophila (Yokoyama, 1958). Several studies have been made on variability of quantitative characters of silkworm races (Jolly *et al.*, 1989; Mukherjee *et al.*, 1999 and Kumaresan *et al.*, 2000). Moreover, the morphological traits are oligogenic in nature, inherited under Mendelian genetics and these traits have direct or indirect relation with other quantitative traits. These non-numeric parameters play an indirect basis for selection of parent stocks (initial material). Spearman's rank correlation coefficient analysis helps to measure the degree and direction of mutual relationship between numeric and non-numeric parameters. Though not much information is available in the aspects, an attempt was made to study the linear relationship among 8 economic traits and 4 morphological parameters of 56 multivoltine silkworm accessions and subsequent selection of elite silkworm germplasm based on evaluation index with correlated morphological traits.

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MATERIALS AND METHODS

Fifty-six multivoltine mulberry silkworm accessions collected from different regions were used in the present study. These races are maintained in the Germplasm Bank of the Central Sericultural Germplasm Resources Centre, Hosur, Tamil Nadu. The experiment was conducted in five seasons during 2001 in randomized block design with two replications of 300 larvae each and observations were recorded on 8 quantitative traits of commercial value, such as weight of 10 grown larvae (g), single cocoon weight (g), single shell weight (g), shell ratio (%), cocoon yield by weight (kg)/10,000 larvae, pupation rate (%), total larval duration (h) and fifth age larval duration (h). The standard rearing technique as recommended by Krishnaswamy (1978) was followed.

The morphological parameters of racial importance, *viz.*, larval pattern (Plain/Marked/Sex-limited), haemolymph colour (Colourless/yellow), cocoon colour (White/Greenish yellow/Golden yellow/Yellow/Light greenish yellow) and cocoon shape (Dump bell/Spindle/Oval/Elongated oval) were characterized for all the 56 multivoltine silkworm accessions. The numerical data were subjected to ANOVA and Spearman's rank correlation coefficient analysis was done using the computer packages developed by Indostat Service Pvt. Ltd, Hyderabad, India. For the Spearman's rank correlation analysis, the non-numeric parameters were arranged in order thereby obtaining for each descriptor a number indicating rank in the group. The rank was allotted on the basis of weightage of descriptors. Further the selected quantitative traits were subjected for Evaluation Index (EI) (Mano *et al.*, 1992) and assigned overall rank based on the cumulative superiority for the traits. Evaluation Index value for the breeds could be arrived at by the following formula:

$$\text{Evaluation Index(EI)} = \frac{A - B}{C} \times 10 + 50$$

where

A = Mean of the particular trait
B = Overall mean of the particular trait
C = Standard deviation
10 = Standard
50 = Constant.

The breeds that score index value above 50 are considered to have greater economic value.

RESULTS AND DISCUSSION

The mean performance of fifty-six multivoltine silkworm accessions for all the 8 economic traits is presented in Table 1. The ANOVA indicates that all the 8 quantitative traits are significantly varied from $P < 0.001$ to $P < 0.05$ level among the accessions studied (Table 2).

The Spearman's rank correlation analysis indicates that the quantitative traits, *viz.*, weight of 10 grown larvae, single cocoon weight, single shell weight and shell ratio

TABLE 1. Mean performance of multivoltine silkworm races for quantitative traits and their important morphological characters

Sl. No	Race name	WTG[1]	CWT	SWT	SR	YWT	PR	TLD	VLD	LP	HC	CC	CS
1.	C. NICHI	22.091	1.048	0.125	12.169	8.015	76.651	545.600	132.800	P(4)	CL(4)	W(3)	D(1)
2.	RONG DAIZO	26.957	1.437	0.197	13.916	13.637	79.714	605.600	182.400	M(3)	CL(4)	GRY(4)	SP(2)
3.	GUANGNONG PLAIN	23.455	1.139	0.161	14.265	10.169	78.266	552.600	145.400	P(4)	CL(4)	W(3)	O(3)
4.	RAJ	22.093	1.254	0.179	14.431	10.366	79.905	591.600	167.400	P(4)	CL(4)	W(3)	SP(2)
5.	GNM	24.831	1.254	0.209	16.856	10.276	73.949	565.600	159.000	M(3)	CL(4)	W(3)	O(3)
6.	NISTID(Y)	22.973	1.188	0.155	13.191	10.119	80.397	567.200	151.200	P(4)	Y(3)	GY(2)	SP(2)
7.	NISTID(W)	23.316	1.155	0.153	13.420	10.863	90.990	575.500	156.400	P(4)	CL(4)	W(3)	SP(2)
8.	NK4	24.918	1.273	0.174	13.853	11.840	87.619	584.000	165.000	P(4)	Y(3)	Y(1)	SP(2)
9.	CAMBODG	24.462	1.300	0.195	15.228	9.940	71.543	584.000	165.600	P(4)	Y(3)	Y(1)	SP(2)
10.	DAIZO	19.753	1.002	0.135	13.730	6.120	76.484	581.400	180.000	M(3)	CL(4)	GRY(4)	SP(2)
11.	PURE MYSORE	20.136	1.274	0.174	13.771	10.092	65.390	681.000	198.600	P(4)	CL(4)	LGY(4)	SP(2)
12.	SARUPAT	25.107	1.224	0.175	14.507	11.712	82.631	548.800	140.200	P(4)	CL(4)	W(3)	SP(2)
13.	MORIA	25.870	1.269	0.189	15.074	11.797	88.698	564.200	147.800	P(4)	CL(4)	W(3)	SP(2)
14.	TAMIL NADU WHITE	25.553	1.178	0.171	14.630	10.163	76.797	559.400	147.800	P(4)	CL(4)	W(3)	SP(2)
15.	HOSA MYSORE	27.286	1.388	0.223	16.126	11.723	80.643	575.200	154.000	P(4)	CL(4)	GRY(4)	EL(4)
16.	MYSORE PRINCESS	30.073	1.457	0.226	15.629	13.112	81.457	560.400	146.200	P(4)	CL(4)	W(3)	O(3)
17.	KOLAR GOLD	29.106	1.445	0.227	15.799	12.203	76.365	571.400	152.000	P(4)	CL(4)	W(3)	O(3)
18.	KOLLEGAL JAWAN	29.277	1.384	0.213	15.554	12.315	73.571	568.200	149.600	P(4)	CL(4)	W(3)	O(3)
19.	MY-1	25.822	1.345	0.185	13.907	12.168	77.225	588.400	169.000	P(4)	CL(4)	LGY(4)	EL(4)
20.	P2D1	26.489	1.337	0.184	13.984	11.963	79.159	572.400	159.200	P(4)	CL(4)	GRY(4)	ELO(4)
21.	OS-616	25.039	1.313	0.202	15.444	12.256	83.606	576.000	158.600	M(3)	Y(3)	Y(1)	O(3)
22.	G	25.964	1.200	0.178	15.000	10.237	75.938	561.600	150.400	M(3)	Y(3)	GY(2)	O(3)
23.	NISTARI	25.404	1.259	0.168	13.558	9.664	77.830	550.200	140.400	M(3)	Y(3)	GY(2)	SP(2)
24.	NISTARI(M)	24.723	1.139	0.158	14.058	10.880	83.778	568.600	155.600	M(3)	Y(3)	GY(2)	SP(2)
25.	NISTARI(P)	25.324	1.242	0.163	13.261	10.698	81.703	565.400	148.400	P(4)	Y(3)	GY(2)	SP(2)
26.	ZPN(SL)	18.216	1.072	0.155	14.791	9.323	78.242	581.200	162.800	SL(3)	CL(4)	W(3)	SP(2)
27.	CB5	26.308	1.287	0.199	15.685	11.322	81.153	565.200	161.600	M(3)	Y(3)	GY(2)	O(3)
28.	KW2	20.544	1.035	0.142	13.843	8.197	65.629	580.200	156.600	P(4)	CL(4)	W(3)	ELO(4)
29.	M2	25.469	1.367	0.199	14.688	11.676	87.463	567.200	154.800	M(3)	Y(3)	GY(2)	O(3)
30.	A23	24.070	1.270	0.169	13.348	12.040	84.985	570.600	155.600	M(3)	Y(3)	GY(2)	O(3)

TABLE 1. Continued

Sl. No.	Race name	WTG[1]	CWT	SWT	SR	YWT	PR	TLD	VLD	LP	HC	CC	CS
31.	A25	27.548	1.409	0.220	15.787	13.503	86.113	575.600	162.800	M(3)	Y(3)	GY(2)	ELO(4)
32.	OVAL	26.512	1.378	0.204	15.079	11.920	83.294	569.600	157.600	M(3)	Y(3)	GY(2)	O(3)
33.	O	24.831	1.301	0.205	15.962	12.123	90.808	571.600	158.600	M(3)	Y(3)	GY(2)	O(3)
34.	M83(C)	26.531	1.308	0.203	15.562	11.329	85.033	562.400	152.200	M(3)	Y(3)	GY(2)	O(3)
35.	B	22.835	1.167	0.167	14.325	11.000	88.961	565.600	153.600	P(4)	Y(3)	GY(2)	EL(4)
36.	A14DY	26.526	1.305	0.181	13.977	11.097	81.978	568.600	157.400	M(3)	Y(3)	GY(2)	O(3)
37.	A4E	25.964	1.424	0.221	15.752	12.446	83.157	581.000	161.800	M(3)	CL(4)	GRY(4)	ELO(4)
38.	PA12	25.393	1.414	0.218	15.525	11.409	74.834	598.800	169.000	P(4)	CL(4)	GRY(4)	ELO(4)
39.	AP12	27.818	1.461	0.239	16.486	11.539	73.948	590.200	172.400	P(4)	CL(4)	GRY(4)	ELO(4)
40.	A13	29.016	1.297	0.182	14.220	12.006	83.898	564.400	150.200	P(4)	CL(4)	GRY(4)	ELO(4)
41.	PMX	27.197	1.374	0.208	15.249	11.233	76.158	563.000	145.400	P(4)	CL(4)	LGY(4)	ELO(4)
42.	PMS2	28.867	1.339	0.199	14.973	11.324	84.785	564.000	150.200	P(4)	CL(4)	LGY(4)	ELO(4)
43.	MU-1	29.113	1.406	0.207	14.890	11.563	79.485	567.000	153.000	P(4)	CL(4)	LGY(4)	EL(4)
44.	MU-11	27.663	1.385	0.209	15.280	11.792	76.048	586.800	168.600	P(4)	CL(4)	LGY(4)	ELO(4)
45.	WAI-1	29.229	1.393	0.206	14.959	12.930	87.072	576.600	157.000	P(4)	CL(4)	LGY(4)	ELO(4)
46.	WAI-4	24.251	1.270	0.218	17.277	10.149	83.665	569.600	141.800	M(3)	Y(3)	Y(1)	O(3)
47.	MY23	24.957	1.243	0.163	13.162	9.566	72.417	553.000	140.800	P(4)	CL(4)	GRY(4)	ELO(4)
48.	MW13	26.859	1.413	0.212	15.068	10.320	65.693	577.200	154.400	P(4)	CL(4)	W(3)	O(3)
49.	MHMP(W)	25.959	1.286	0.198	15.509	10.272	65.557	580.600	156.600	P(4)	CL(4)	W(3)	ELO(4)
50.	MHMP(Y)	26.690	1.361	0.205	15.167	11.746	82.671	579.800	161.800	P(4)	CL(4)	GRY(4)	ELO(4)
51.	P4D3	27.057	1.399	0.222	16.041	9.384	79.241	589.000	173.000	P(4)	CL(4)	GRY(4)	ELO(4)
52.	LMP	25.725	1.259	0.182	14.664	10.656	84.017	563.000	149.800	M(3)	Y(3)	GY(2)	SP(2)
53.	DMR	24.925	1.258	0.197	15.726	10.277	82.289	577.600	161.400	M(3)	Y(3)	GY(2)	O(3)
54.	LMO	23.362	1.233	0.189	15.482	11.800	93.746	561.000	147.800	M(3)	Y(3)	GY(2)	O(3)
55.	MY1(SL)	27.637	1.319	0.190	14.455	10.995	77.588	579.800	163.200	SL(3)	CL(4)	LGY(4)	EL(4)
56.	PM(SL)	25.907	1.299	0.178	13.792	10.940	78.341	578.000	154.400	SL(3)	CL(4)	LGY(4)	ELO(4)

* WTG = Weight of 10 grown larvae (g); CWT = Single cocoon weight (g); SWT = Single shell weight (g); SR = Shell ratio (%); YWT = Cocoon yield by weight (kg)/10,000 larvae; PR = Pupation rate (%); TLD = Total larval duration (hour); VLD = Fifth age larval duration (hour); LP = Larval pattern; HC = Haemolymph colour; CC = Cocoon colour; CS = Cocoon shape; P = Plain; M = Marked; SL = Sex limited; CL = Colourless; Y = Yellow; W = White; GRY = Greenish yellow; LGY = Light greenish yellow; GY = Golden yellow; D = Dumb bell; SP = Spindle; O = Oval; EL = Elongated; ELO = Elongated Oval. Figures in paranthesis indicate weightage alloted for variables.

TABLE 2. Variability in quantitative traits of 56 multivoltine silkworm races

Parameters	Mean	SD	Minimum	Maximum	ANOVA (MSS)	
					Race	Error
Weight of 10 grown larvae (g)	25.518	3.899	18.216	30.072	30.423***	9.3171
Single cocoon weight (g)	1.289	0.136	1.002	1.457	0.059***	0.0067
Single shell weight (g)	0.189	0.031	0.125	0.239	0.003***	0.0003
Shell ratio (%)	14.787	1.458	12.169	16.856	5.188***	1.1241
Cocoon yield by weight (kg)/10,000 larvae	11.034	2.676	6.120	13.637	8.960***	3.7805
Pupation rate (%)	79.975	16.412	65.557	93.746	200.533*	139.8065
Total larval duration (hour)	573.968	42.689	545.600	681.000	1788.653***	356.4258
Fifth age larval duration (hour)	157.021	22.138	132.800	198.600	633.576**	142.9395

*** Significance at $P < 0.001$; ** Significance at $P < 0.01$; * Significance at $P < 0.05$.

have significant positive correlation among them. It was also found that the single cocoon weight has significant positive correlation with total ($r = +0.321$) as well as fifth age larval duration ($r = +0.303$). This finding corroborates the observation made by Jayaswal *et al.* (1990). The pupation rate was negatively correlated with most of the economic traits but positively correlated with cocoon yield by weight/10,000 larvae ($r = +0.440$). This observation is in agreement with earlier report (Kumaresan *et al.*, 2000).

The correlation studies among the non-numeric parameters indicated significant positive correlation between cocoon colour and cocoon shape ($r = +0.539$); the cocoon colour with larval pattern ($r = +0.392$) and haemolymph colour ($r = +0.860$). Similarly, the haemolymph colour and cocoon shape has positively correlated ($r = +0.318$). The colour of haemolymph is corresponding with the cocoon colour (Yokoyama, 1958). The cocoon colour and shape are fixed characters of the breeds of silkworm (Kovalev, 1970). The cocoon shape is determined by the spinning behavior of the larvae (Rama Mohana Rao and Nakada, 1998). According to Nakada (1989), from the view point of genetic differentiation and race formation of silkworm, the cocoon shape may be helpful in tracing out the genetic relationship among the strains. Further, the shape, size and colour of cocoon differ with the geographical distribution of silkworm races (Tanaka, 1964).

TABLE 3. Spearman's rank correlation coefficient on numeric and non-numeric parameters of 56 multivoltine silkworm races

Parameters	WTG[1]	CWT	SWT	SR	YWT	PR	TLD	VLD	LP	HC	CC	CS
WTG	—	0.808**	0.729**	0.423**	0.616**	−0.020	−0.052*	−0.016	0.154	0.261	0.448**	0.509**
CWT		—	0.876**	0.516**	0.698**	−0.061	0.321*	0.303*	0.107	0.219	0.368**	0.518**
SWT			—	0.843**	0.601**	−0.047	0.224	0.208	0.035	0.157	0.253	0.500**
SR				—	0.356**	0.028	0.140	0.138	−0.138	−0.019	0.006	0.329*
YWT					—	0.440**	0.104	0.185	0.017	0.024	0.170	0.313*
PUPA						—	−0.242	−0.147	−0.286*	−0.485**	−0.330*	−0.143
TLD							—	0.852**	0.024	0.197	0.187	0.222
VLD								—	−0.125	0.103	0.168	0.198
LP									—	0.553**	0.392**	0.189
HC											0.860**	0.318*
CC											—	0.539**
CS												—

**Significant at 0.01 level (2 tailed); *Significant 0.05 level (2 tailed) [1] WTG = Weight of 10 grown larvae (g), CWT = Single cocoon weight (g), SWT = Single shell weight (g), SR = Shell ratio (%), YWT = Cocoon yield by weight (kg)/10,000 larvae, PR = Pupation rate (%), TLD = Total larval duration (hour), VLD = Fifth age larval duration (hour), LP = Larval pattern, HC = Haemolymph colour, CC = Cocoon colour, CS = Cocoon shape.

TABLE 4. Evaluation index values in respect of selected quantitative traits of multivoltine silkworm races

Sl. No.	Race name	Weight of 10 grown larvae	Single cocoon weight	Single shell weight	Shell ratio	Cocoon yield by Weight/ 10,000 larvae	Cumulative superiority
1	MYSORE PRINCESS	61.68	62.35	61.94	55.78	57.77	59.90
2	AP12	55.90	62.65	66.13	61.65	51.89	56.64
3	KOLAR GOLD	59.20	61.47	62.26	56.94	54.37	58.85
4	A25	55.21	58.82	60.00	56.86	59.23	58.02
5	HOSA MYSORE	54.53	57.28	60.97	59.18	52.57	56.91
6	KOLLEGAL JAWAN	59.64	56.99	57.74	55.26	54.79	56.88
7	A4E	51.14	59.93	60.32	56.62	55.28	56.66
8	WAI-1	59.52	57.65	55.48	51.18	57.09	56.18
9	MU-1	59.22	58.60	55.81	50.71	51.98	55.26
10	MU-11	55.50	57.06	56.45	53.38	52.83	55.05
11	P4D3	53.95	58.09	60.65	58.60	43.83	55.02
12	PA12	49.68	59.19	59.35	55.06	51.40	54.94
13	RONG DAIZO	53.69	60.88	52.58	44.03	59.73	54.18
14	PMX	54.31	56.25	56.13	53.17	50.74	54.12
15	OVAL	52.55	56.54	54.84	52.00	53.31	53.85
16	MW13	53.44	59.12	57.42	51.93	47.33	53.85
17	MHMP(Y)	53.01	55.29	55.16	52.61	52.66	53.75
18	WAI-4	46.75	48.60	59.35	67.08	46.69	53.70
19	PMS2	58.59	53.68	53.23	51.28	51.08	53.57
20	O	48.24	50.88	55.16	58.06	54.07	53.28
21	M83(C)	52.60	51.40	54.52	55.32	51.10	52.99
22	OS-616	48.77	51.76	54.19	54.51	54.57	52.76
23	GNM	48.24	47.43	56.45	64.19	47.17	52.69
24	CB5	52.03	49.85	53.23	56.16	51.08	52.47
25	M2	49.94	55.74	53.23	49.32	52.40	52.12
26	A13	58.97	50.59	47.74	46.11	53.63	51.41
27	MHMP(W)	51.13	49.78	52.90	54.95	47.15	51.18
28	MY1(SL)	55.43	52.21	50.32	47.72	49.85	51.11
29	MORIA	50.90	48.53	50.00	51.97	52.85	50.85
30	DMR	48.48	47.72	52.58	56.44	47.17	50.48
31	P2D1	52.49	53.53	48.39	44.49	53.47	50.47
32	MY-1	50.78	54.12	48.71	43.96	54.24	50.36
33	CAMBODG	47.29	50.81	51.94	53.02	45.91	49.79
34	LMO	44.47	45.88	50.00	54.77	52.86	49.60
35	A14DY	52.59	51.18	47.42	44.44	50.24	49.17
36	LMP	50.53	47.79	47.74	49.16	48.59	48.76
37	SARUPAT	48.95	45.22	45.48	48.08	52.53	48.05
38	PM(SL)	51.00	50.74	46.45	43.18	48.53	47.98
39	G	51.14	43.46	46.45	51.46	47.02	47.91
40	NK4	48.46	48.82	45.16	43.59	53.01	47.81
41	A23	46.29	48.60	43.55	40.13	53.76	46.47
42	TAMIL NADU WHITE	50.09	41.84	44.19	48.92	46.75	46.36

TABLE 4. Continued.

Sl. No.	Race name	Weight of 10 grown larvae	Single cocoon weight	Single shell weight	Shell ratio	Cocoon yield by Weight/10,000 larvae	Cumulative superiority
43	RAJ	41.22	47.43	46.77	47.56	47.50	46.10
44	NISTARI	49.71	47.79	43.23	41.57	44.88	45.44
45	NISTARI(P)	49.50	46.54	41.61	39.53	48.74	45.19
46	B	43.12	41.03	42.90	46.83	49.87	44.75
47	NISTARI(M)	47.96	38.97	40.00	45.00	49.42	44.27
48	MY23	48.56	46.62	41.61	38.85	44.51	44.03
49	PURE MYSORE	36.20	48.90	45.16	43.03	46.48	43.95
50	GUANGNONG PLAIN	44.68	38.97	40.97	46.42	46.77	43.56
51	NISTID(W)	44.35	40.15	38.39	40.62	49.36	42.57
52	NISTID(Y)	43.47	42.57	39.03	39.05	46.58	42.14
53	ZPN(SL)	31.27	34.04	39.03	50.03	43.61	39.60
54	KW2	37.24	31.32	34.84	43.53	39.40	37.27
55	C.NICHI	41.21	32.28	29.35	32.04	38.72	34.72
56	DAIZO	35.21	28.90	32.58	42.75	31.64	34.22

The correlation studies between numeric and non-numeric parameters indicated that the cocoon colour has significant positive correlation with weight of 10 grown larvae ($r = +0.448$) and single cocoon weight ($r = +0.368$). Similarly, the cocoon shape was positively correlated with 5 major economic parameters, *viz.*, weight of 10 grown larvae ($r = +0.509$), single cocoon weight ($r = +0.518$), single shell weight ($r = +0.500$), shell ratio ($r = +0.329$) and cocoon yield by weight/10,000 larvae ($r = +0.313$) (Table 3). Since the cocoon colour and cocoon shape were positively correlated with most of the important economic parameters as well as other non-numeric parameters, it is suggested that both parameters could be used as indirect means for further selection of best silkworm accessions.

Evaluation index (Mano *et al.*, 1992) method is one of the best methods adopted for selection of elite silkworm parental materials from germplasm stocks for further improvement (Nirmal kumar and Sreerama Reddy, 1994; Ramesh Babu *et al.*, 2001). The five economic parameters, *viz.*, weight of 10 grown larvae, single cocoon weight, single shell weight, shell ratio and cocoon yield by weight/10,000 larvae having positive correlation with cocoon colour and cocoon shape were subjected to score the index value based on Evaluation index method and assigned overall rank based on cumulative superiority for the traits (Table 4). The results indicated that most of the top ranked 10 elite silkworm accessions, *viz.*, Mysore Princess, AP12, Kolar Gold, A25, Hosa Mysore, Kollegal Jawan, A4E, WAI-1, MU-1, and MU-11 have the same cocoon colour of greenish yellow (6 accessions) and the same cocoon shape of elongated oval (7 accessions); besides most of them have plain larva with colourless haemolymph. The results suggest that among the available multivoltine silkworm germplasm, the accessions that have greenish yellow coloured and elongated oval shaped cocoon have shown maximum yield potential and such accessions may be used in the breeding programme.

Thus, the above selected elite silkworm accessions could be used as better initial materials for the improvement of correlated traits. Further, the analysis emphasize that the non-numeric parameters such as cocoon colour and cocoon shape could be used as indirect means for selecting the elite parental lines from the germplasm stocks.

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Whiteflies (Hemiptera: Aleyrodidae) associated with sandal (*Santalum album* L.) in southern India with description of a new species

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ABSTRACT: Three species of whiteflies *viz.*, *Dialeurodes icfreae* sp. n, *Aleurocanthus martini* David and *Aleurodicus dispersus* Russell were found breeding on *Santalum album* L. in south India. The new species is described and illustrated and *A. marini* is redescribed with illustration. © 2003 Association for Advancement of Entomology

KEYWORDS: Aleyrodidae, whitefly, *Dialeurodes icfreae*, *Aleurocanthus martini*, *Aleurodicus dispersus*

INTRODUCTION

Santalum album L. (Santalaceae) is one of the important tree species of India, having a high economic value. It is widely distributed in the country, with more than 90% of its population in Karnataka and Tamil Nadu (South India). More than 150 species of insects have been reported on sandal but, little information is available on the whileflies breeding on it. Prathapan (1996) reported *Aleurodicus dispersus* on sandal in South India. In Australia, *Aleuroduplidens santali* is reported to infest *Santalum lanceolatum* (Martin, 1999). In the present study, we found in addition to *A. dispersus*, two species of aleyrodids, *viz.*, *Dialeurodes icfreae* sp. n. and *Aleurocanthus martini* David on sandal. The new species *D. icfreae* is described and *A. martini* David is redescribed with illustration.

MATERIALS AND METHODS

The study was largely based on the materials collected by the authors from different localities of Western Ghats of South India. The whitefly infested leaves of sandal were collected and the best mounts were obtained from puparia from which adults have emerged.

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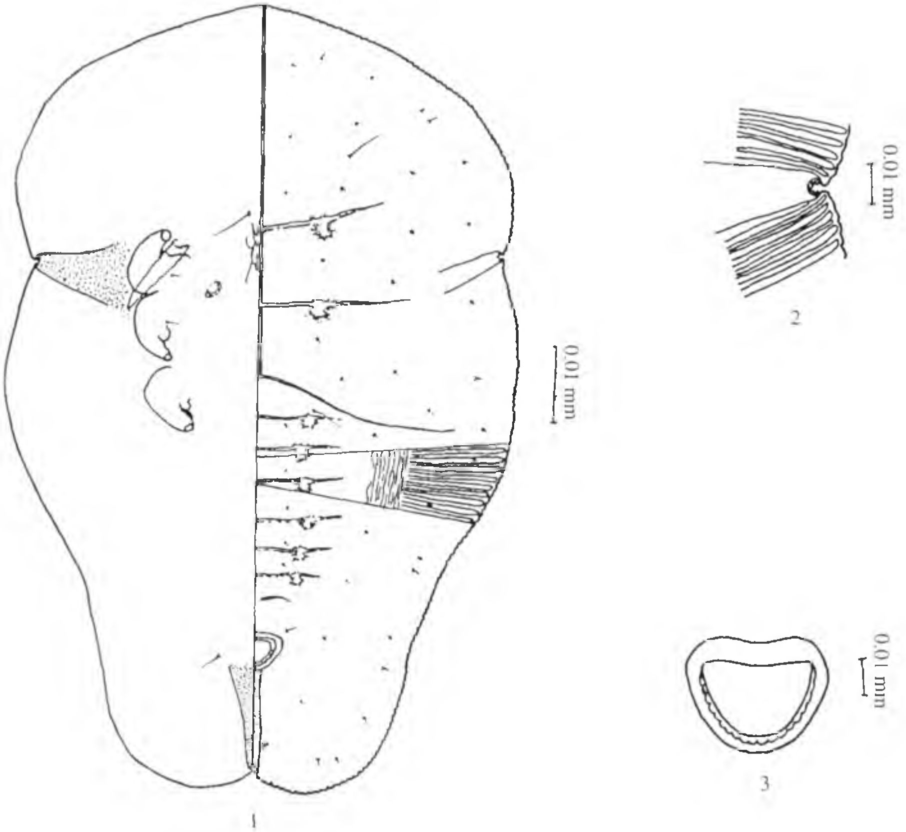

Figure 1–3: *Dialeurodes icfreae* sp. n. 1: Puparium, 2: Thoracic tracheal pore, 3: Vasiform orifice.

RESULTS AND DISCUSSION

Description

Dialeurodes icfreae sp. nov.

Puparium White without wax; elliptical, constricted at the thoracic tracheal pores and posterior abdominal region with deep invagination at caudal tracheal pore region, widest across the transverse moulting suture; measures 0.98–0.99 mm long, 0.63–0.66 mm wide (Fig. 1); found on the upper surface of leaf. Margin smoothly crenulate, 4-5 crenulations in 0.1 mm; thoracic and caudal tracheal pore regions indicated as invaginated clefts with chitinized rim having irregular teeth (Fig. 2). Anterior and posterior marginal setae respectively, 7 and 9 μm long.

Dorsum Submargin not separated from dorsal disc, with a row of minute setae, each 3 μm long, submarginal striations reaching subdorsal area. Subdorsum with wavy

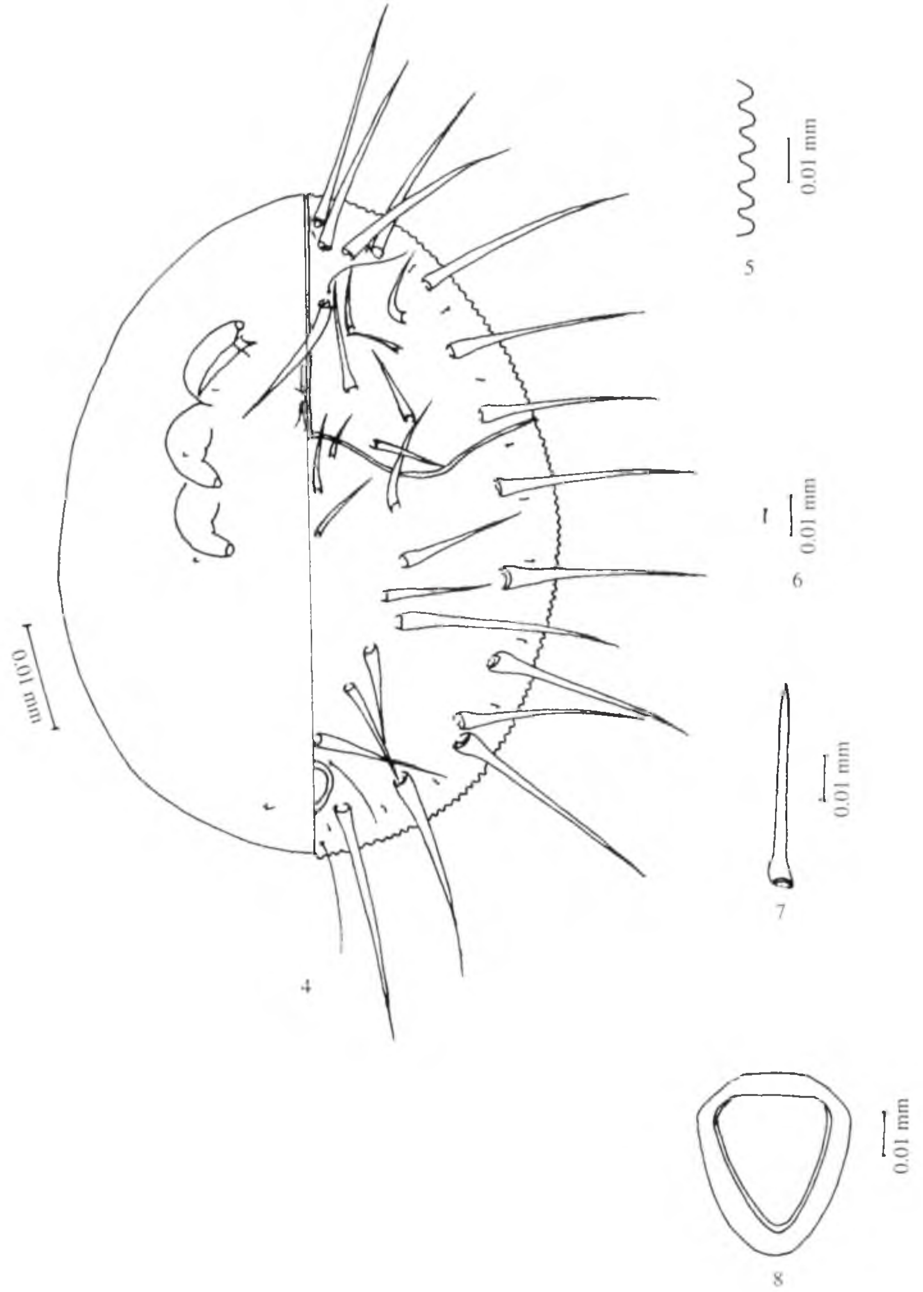

Figure 4–8: *Aleurocanthus martini* David 4: Puparium, 5: Margin, 6: Capitate seta, 7: Spine, 8: Vasiform orifice.

markings. Abdominal segments I–IV subequal in length, median length of abdominal segment VII shorter than VIII. Submedian pockets present in all the cephalothoracic and abdominal segment sutures. Submedian depressions faintly discernible in all the segments. Longitudinal moulting suture reaching margin and transverse moulting suture reaching submargin. Minute pores with porettes scattered throughout the dorsum. Pockets not contiguous (Fig. 1).

Chaetotaxy Three pairs of setae-cephalic setae 26 μm long, first abdominal setae 20 μm long and eight abdominal setae cephalolateral of vasiform orifice 16 μm long. Vasiform orifice. subcircular, wider than long, 34–36 μm long, 40–42 μm wide, inner posterior and lateral wall of orifice with a comb of teeth; operculum similarly shaped, 30–32 μm long, 32–34 μm wide, filling the orifice and obscuring the lingula. Thoracic tracheal furrows broad. Caudal tracheal furrow narrow with fine dots, 106 μm long, 38 μm wide at its widest end. A pair of minute setae, slightly above the caudal tracheal pore 3 μm long distinct (Fig. 3).

Venter Paired ventral abdominal setae 10 μm long, 52 μm apart. Thoracic and caudal tracheal folds distinct with stipples. A pair of setae at the base of rostrum 23 μm long present. Minute setae at base of pro- and mesothoracic legs 5 μm long evident. Antennae reaching base of prothoracic legs.

Material examined

Holotype puparium, India: Tamil Nadu, Javadu hills, one puparium on slide, *Santalum album*, 19.iii.2001, A. K. Dubey, deposited in Forest Entomology Division, Forest Research Institute, Dehra Dun; Paratype, one puparium on slide with data as of holotype, deposited in the collection of Prof. B. V. David, Chennai, India.

Etymology

The name of this species refers to the acronym for Indian Council of Forest Research and Education (ICFRE), Dehra Dun, India.

Comments

This species is typical in its shape from all other known species of *Dialeurodes*. It comes close to *D. vitis* Corbett in the puparium narrowing posteriorly but differs from it in the absence of tubercles on dorsum and in the presence of inner teeth in thoracic and caudal tracheal pores.

Aleurocanthus martini David

Aleurocanthus martini David, 1993. The Whitefly of Sri Lanka, Fredrick Institute of Plant Protection and Toxicology Entomological series, **3**:12.

David (1993) described *A. martini* for Sri Lanka on *Sebastiana chamelia*. This species is redescribed as the original description has been found inadequate. Further this is the first report of occurrence of this species in India.

Puparium Black, surrounded by thick fringe of white wax; elliptical, 0.92–1.12 mm long and 0.68–0.85 mm wide, widest across the second abdominal segment region (Fig. 4); found 5–8 per leaf, in groups on the lower surface of leaves. Margin regularly teethed, 7–9 teeth in 0.1 mm. Anterior and posterior marginal setae absent. Teeth not modified at thoracic and caudal tracheal openings (Fig. 5).

Dorsum Dorsum with 31 pairs of pointed spines with glandular bases, slightly depressed (Fig. 7), 14 pairs on cephalothorax and 17 pairs on abdomen. Of the 14 pairs on cephalothorax- 5 subdorsal, 100–116 μm long, 9 submedian, 36–102 μm long and of the 17 pairs on abdomen- 7 subdorsal, 104–114 μm long, 3 on inner submedian area, 34–90 μm long and 7 on outer submedian area 38–56 μm long, 3rd and 4th posterior abdominal spines very close to base on subdorsal area. A row of minute capitate setae (Fig. 6) on submargin present. Longitudinal and transverse moulting sutures reaching margin (Fig. 4).

Chaetotaxy Three pairs of setae- cephalic setae 88 μm long, eighth abdominal setae 94 μm long and caudal setae 178 μm long. First abdominal setae absent. Vasiform orifice. elevated, cordate, 60–76 μm long, 50–66 μm wide, longer than wide, many finger-like processes on ventral side between the inner wall of vasiform orifice and operculum present; operculum subcordate shaped, 42–56 μm long, 36–40 μm wide, filling the orifice and obscuring the lingula (Fig. 8). Tracheal furrows absent.

Venter Ventral abdominal setae not discernible but bases distinct, 33 μm apart. Minute setae at base of legs absent. Thoracic and caudal tracheal folds absent. Adhesive sacs visible. Antennae reaching to base of prothoracic legs. Spiracles visible.

Material examined

India: Karnataka, Bangalore, ten puparia on slide, *Santalum album*, 26.iii.2001. A. K. Dubey, deposited in the collection of senior author.

Aleurodicus dispersus Russell

Aleurodicus dispersus Russell, 1965. *The Florida Entomologist*, **48**: 49–54.

Material examined

India: Karnataka, Bangalore, 22 puparia mounted on slides, *Santalum album*, 12.viii.1999. R. Sundararaj, deposited in the collection of senior author.

In the global catalogue of whiteflies (Mound and Halsey, 1978) no whitefly species was listed from Santalaceae. Prathapan (1996) reported for the first time occurrence of *A. dispersus* on *S. album* in India. Martin (1999) described *Aleuroduplidens santali* on *S. lanceolatum* from Australia.

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A review of the oriental species of *Megastigmus* Dalman (Hymenoptera: Torymidae)

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ABSTRACT: The Oriental species of *Megastigmus* Dalman is reviewed. The new species *M. karnatakensis* Narendran is described. A key to the Oriental species and notes on each known species are provided.

KEYWORDS: Review, *Megastigmus*, key, new species, Oriental

INTRODUCTION

The genus *Megastigmus* Dalman contains 126 species in the world and six species are so far reported from the Oriental region (Grissell, 1999). From India only four species are so far known (Narendran, 1994; Grissell, 1999). In this paper a new species from Karnataka (India) is described. A key to Oriental species and notes on each known species are provided.

Abbreviations used

F1 to F8 = Funicular segments 1 to 8; MV = Marginal vein; PMV = Post marginal vein; STV = Stigmal vein; OOL = Ocellocular distance; POL = Post ocellar distance; WWII = World War II.

Depositories: BMNH = The Natural History Museum, London; DZUC = Department of Zoology, University of Calicut; FRI = Forest Research Institute, Dehra Dun; IARI = Indian Agricultural Research Institute, New Delhi; IEUN = Institute de Entomologia, Agraria, Universita degli di Napoli, Portici, Italy; QM = Queensland Museum, Australia; MNHN = Museum National d' Histoire Naturelle Paris, France; NMW = Natural historisches Museum, Vienna, Austria; USNM = United States National Museum of Natural History, Washington DC.

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Key to Oriental species of *Megastigmus* Dalman

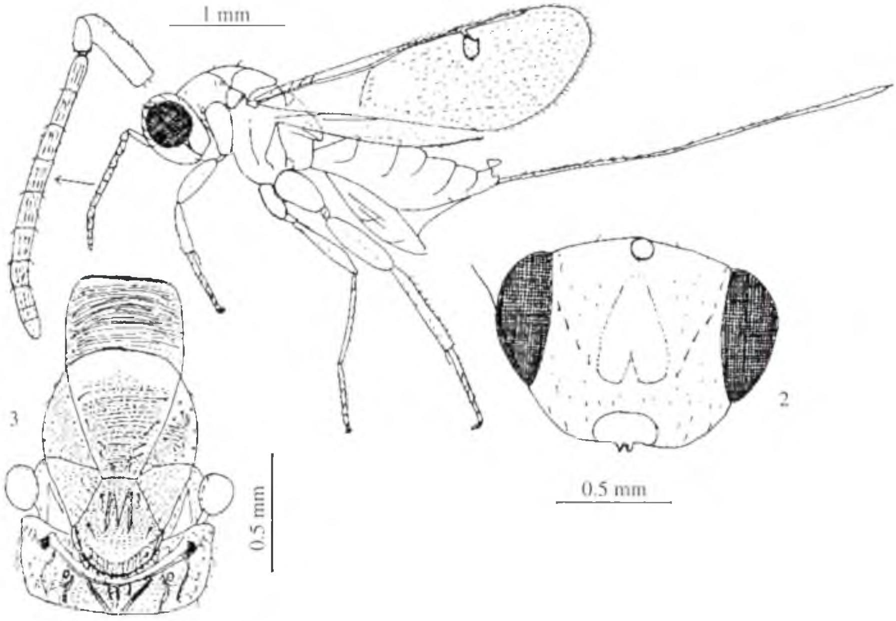
(Based on females)

1. F1 distinctly longer than combined length of pedicel and ring segment 2
= F1 shorter than (or at the most equal to) combined length of pedicel and ring segment 3
2. Length of ovipositor 1.25× combined length of mesosoma and metasoma (166 : 200); body yellow; Philippines .... *M. immaculatus* Ashmead
= Length of ovipositor 1.09× combined length of mesosoma and metasoma (160 : 91.66); body yellow with dark tinge or patches on some parts of mesosoma and metasoma; Java. Host: Fruits of *Dalbergia sericea* .... *M. leeuweni* Ferriere
3. Mesosoma dorsally metallic green; F1 equal to pedicel and ring segment combined; host: parasitic on cynipidae on *Quercus*; Europe & India (Uttar Pradesh) .... *M. dorsalis* (Fabricius)
= Mesosoma dorsally yellowish brown; F1 shorter than pedicel and ring segment combined 4
4. Ring segment of antenna about half as long as pedicel; forewing with stigmal lobe narrow and elongate; basal vein weakly distinct; India (Himachal Pradesh); hosts: seeds of *Cupressus torulosa* .... *M. cupressi* Mathur
= Ring segment distinctly shorter than half of pedicel; forewing with stigmal lobe not as above, mostly oval or semicircular; basal vein clearly distinct 5
5. Ovipositor sheath 1.4 to 1.5× as long as metasoma; propodeum without a median carina; metasoma about 1.8× length of hind tibia. Host: Pods of *Albizzia*, India (Delhi) .... *M. albizziae* Mukerji
= Ovipositor more than 2× longer than metasoma (2.2×); propodeum atleast with a short median carina (often incomplete); metasoma less than 1.7× as long as hind tibia; host different 6
6. Frenum nearly smooth; lower clypeal margin not distinctly bilobed or incised at middle (nearly entire); ovipositor 2.2× as long as metasoma; F1 longer than F2; MV about 2.5× as long as STV; POL 1.2× OOL; Host: bud galls of *Calycopterys floribunda* .... *M. viggianii* Narendran and Sureshan
= Frenum longitudinally rugose; lower clypeal margin incised in the middle; ovipositor 2.7× as long as metasoma; F1 shorter than F2; MV about 3× as long as STV; POL 2.3× OOL; Hosts: Psychid (*Pteroma* sp.) from *Rhizophora mucronata* and parasitic on borers of *Sonneratia* seeds *M. karnatakensis* Narendran sp. nov.

***Megastigmus karnatakensis* Narendran sp. nov.**

Female (Figs 1–3)

Holotype length: 3.15 mm (excluding ovipositor sheath); ovipositor sheath length 3.52 mm. General body colour pale brownish yellow with metasoma a little darker; ovipositor sheath black; wings hyaline; stigma of forewing dark brown; veins pale brown; pubescence in general pale brownish yellow with stouter setae on head and mesosoma darker.



FIGURES 1–3: *Megastigmus karnatakensis* Narendran sp. nov. Female 1. Body profile; 2. Head front view; 3. Mesosoma.

Head

Width in dorsal view a little over 2.2× its maximum dorsal length, a little broader than mesoscutum; in anterior view head width a little over 1.3× its median length; vertex convex, cross striate, with bristles black; lateral ocellus about 1.2× OOL; POL 2.3× OOL; occiput moderately emarginate; vertex with four large brown setae on occipital margin submedially; an oblique line of strong setae on each parascrobal space (Fig. 2); clypeus demarcated with lower margin incised. Antenna inserted a little above level of ventral margin of eye; antennal formula 11173; scape not reaching front ocellus, a little longer than transverse diameter of eye; pedicel as long as first funicular segment; ring segment shorter than half of pedicel; F1 shorter than F2; length of clava subequal to combined length of two preceding segments, with area of micropilosity almost extending from tip to base of clava.

Mesosoma

Length about 2× its maximum width (excluding tegula); pronotum 1.7× as broad as long, transversely striate; mesoscutum anterior one third smooth and shiny, remaining part striate-reticulate; striae weaker than those on pronotum; scapulae transversely striate-reticulate; mesoscutum with 5 pairs of setae; each scapula with 6 setae on outer margin, 3 or 4 setae near inner margin. Scutellum as long as broad, transversely

reticulate, with a median shallow sulcus which becomes broader basally, and with a pair of submedian lines (can be seen only under certain illuminations); scutellum with 3 pairs of setae (one pair at the frenal area); frenal furrow distinct, frenum longitudinally rugose; dorsellum smooth. Propodeum 0.4× length of scutellum, with submedian grooves and several median shallow short grooves; surface of propodeum transversely and irregularly reticulate. Forewing (Fig. 1) length 3.17× its maximum width; costal cell narrow with pubescence on dorsal and ventral sides in distal half; proximal half bare, basal cell bare, open basally, speculum present, closed behind; marignal vein a little shorter than half length of costal cell, subequal to postmarginal; stigmal 1.5× as long as broad; legs with minute pubescence; hind tibia with a row of setae dorsally.

Metasoma

Longer than (excluding ovipositor sheath) mesosoma: first tergite deeply emarginate on posterior margin; ovipositor sheath distinctly longer than combined length of mesosoma and metasoma (88 : 107), 2.7× as long as mesosoma.

Male

Differs from female as follows: Length 2.8 mm. Mesoscutum darker; metasoma black with a median paler band; clava longer than two preceding segments combined but shorter than combined length of three preceding segments; costal cell densely pilose on distal one-third ventrally; basal cell with a few hairs apically; stigma 1.33× as long as broad; metasoma distinctly shorter than mesosoma.

Type material

Holotype: Female: India, Karnataka, Udupi, Coll. B. Raji, 24.i.2002. Emerged from Psychid (*Pteroma* sp.) larvae in *Rhizophora mucronata*. Paratypes: 1 Female and 2 males: Karnataka, Coondapur, Coll. B. Rai 18.x.2001; parasitic on seed borers of *Sonneratia*. All types in DZUC.

Host

Psychid larvae (*Pteroma*) and seed borers of *Sonneratia*.

Megastigmus viggianii

Narendran & Sureshan *Megastigmus viggianii* Narendran and Sureshan 1988: 38–42. Holotype female, India (QM).

Diagnosis

Female length: 1.67–2.13 mm. General body colour testaceous with brown bands on metasoma; each lateral ocellus with a pigmented brownish patch; vertex and frons smooth; antennal scape never reaching front ocellus; lower clypeal margin not bilobed,

almost enitre; mid lobe of mesoscutum and scutellum with fine reticulation; frenum nearly smooth; propodeum weakly reticulate with a short incomplete median carina and costula; plicae more or less indistinct. Relative lengths of SMV : MV : PMV : STV = 65 : 37 : 36 : 15. Metasoma a little shorter than mesosoma; ovipositor about 2.2× as long as metasoma.

Taxonomy

Narendran (1994), Narendran and Sureshan (1988).

Host

Reared from bud galls of *Calycopterys floribunda* Lamark.

Distribution

India (Kerala).

Remarks

The depository of the holotype was given as IEUN by mistake in the original papers by Narendran and Sureshan (1988) and by Narendran (1994) which was then quoted by Grissell (1999). The holotype is deposited in QM.

***Megastigmus albizziae* Mukerji**

Megastigmus albizziae Mukerji, 1950: 130–132. Holotype female, Delhi (IARI).

Diagnosis

Female length: 3.1 mm (including ovipositor). General body colour yellowish brown; lateral ocelli devoid of patches; vertex and frons smooth but with pits and sparse pilosity, striae weak; antennal scape neraly reaching front ocellus; F1 shorter than F2; clava 1.7× as long as preceding segment; mesoscutum with fine transverse striations, with two longitudinal rows of bristles arranged on adnotaular area and scattered on scapulae; scutellum not striated as mesoscutum but highly reticulated with three pairs of setae; propodeum weakly reticulate and without a median carina; plicae weakly indicated. Relative lengths of forewing veins: SMV : MV : PMV : STV = 50 : 13 : 13 : 8. Metasomal length subequal to mesosoma. Ovipositor sheath 1.4× as long as metasoma.

Taxonomy

Narendran and Sureshan (1988) and Narendran (1994).

Host

The types were reared from seeds of *Albizzia? odoratissima* Narendran (1994) reported the host *Albizzia lebbeck*.

Distribution

India (Delhi, Coimbatore).

***Megastigmus cupressi* Mathur**

Megastigmus cupressi Mathur 1955: 91–92. Holotype Female. Pungala (FRI).

Diagnosis

Length 2.72 mm (excluding ovipositor); general body colour yellowish brown, metasoma darker. Antennal scape slightly longer than clava, 2× as long as F1; ring segment half as long as pedicel; mesoscutum and scutellum finely and transversely reticulate-rugose; propodeum without carinae, coarsely roughened; forewing with stigma narrow and elongate, about 3× as long as wide; PMV slightly longer than MV; ovipositor sheath shorter than body.

Taxonomy

Narendran (1994); Grissell (1999 – catalogue).

Host

The type series was reared from seeds of *Cupressus torulosa*.

Distribution

India (Himachal Pradesh).

Megastigmus dorsalis

(Fabricius) *Ichneumon dorsalis* Fabricius, 1798: 231. Female. France (? MNHN, Bose collection).
Megastigmus bohemanii Ratzeburg, 1848: 182–183. Female. Germany (NMW) (Type probably destroyed in WWII, see Graham 1969 and Grissell, 1999).
Megastigmus xanthopygus Forster, 1859: 110. 2 Female, 2 male Syntypes, England (? NMW).

Diagnosis

Female: Length 1.6–5.3 mm. Vertex between ocelli, pro- and mesonotum medially and propodeum, light metallic green; rest of body light yellow; metasoma brown above; antennae brownish black; length of first funicular segment of antenna equal to combined length of pedicel and ring segment; forewing with dark infuscation below MV; stigma rounded, lacking infumation; metasoma compressed from sides; ovipositor shorter than body.

Taxonomy

Graham (1990), Narendran (1994) and Grissell (1999 – catalogue).

Host

Parasitic on Cynipidae on *Quercus*. Grissell (1999) gave detailed lists of recorded hosts and biology. In India it is reported from 'Cocoons on *Quercus semicarpifolia*' (Mani and Kaul, 1972).

Distribution:

India (Himalayan Valley), Europe.

***Megastigmus immaculatus* Ashmead**

Megastigmus immaculatus Ashmead, 1905: 401. Holotype female. Manila, Luzon, Philippines (USNM).

Since the original description of the species is extremely inadequate for easy recognition of the species, on may request, Dr. E. E. Grissell of Systematic Entmology Laboratory, United States Department of Agriculture, C/o U.S. National Museum of Natural History, Washington DC. kindly examined the holotype preserved at the museum and provided several additional information.

Diagnosis

Female: Length: 1.6 mm. General body colour yellow. Relative lengths of antennal segments: clava = 18; F1 = 12; F2 = 10; F3 = 9; F4=9; F5 = 8; F7 = 8; F8 = 8. Body measurements in lateral view: head = 40; mesosoma = 100; metasoma = 100; ovipositor ca. 160 (curved slightly). The sculpture of propodeum consists of many well developed carinae as follows: from nucha a median carina extends all way to metanotum, but about one-fifth way from metanotum it is interrupted by an inverted U-shaped (semi-circular) carina that bends back to join posterior margin of the propodeum on either side; there are broad, flat-bottomed pits created by irregular carinae on either side of this semicircular carina and post spiracular sulcus and callus have broad, deep pits; all carinae are slightly irregular so that no symmetrical pits are formed, but all very clearly limited.

Taxonomy

Grissell (1999 – Annotated catalogue).

Host

Unknown.

Distribution

Philippines.

Megastigmus leeuweni Ferriere

Megastigmus leeuweni Ferriere, 1929: 144–145, 5 Female syntypes, Buitenzorg, Java, Indonesia (BMNH).

Diagnosis

Female length: 3.5–4.5 mm. General colour clear yellow with some parts mixed with brown. Relative lengths of antennal segments: scape = 7.1; pedicel = 2.5; ring segment = 0.95; F1 = 4; F2 = 3; F3 = 3; F4 = 3.5; F5 = 3; F6 = 3; F7 = 2.9; clava = 6. Forewing length 3× its maximum width: STV including stigma 2× its maximum width. Relative lengths of body parts in lateral view: Head = 6; mesosoma = 19; metasoma = 18; ovipositor sheath = 32.5.

Taxonomy

Grissell (1999 – annotated catalogue).

Host

Types were reared from fruits of *Dalbergia* (formerly *Melletia*) *sericea*.

Distribution

Indonesia, Java.

ACKNOWLEDGEMENTS

One of us (TCN) is grateful to Dr. E. E. Grissell, Systematic Entomology Laboratory, USDA, C/o The U.S. National Museum of Natural History, Washington, DC for kindly providing information on the types preserved in USNM. He is also grateful to Dr. John S. Noyes of the Natural History Museum, London for providing some literature which were not available with him.

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ENTOMON **28(4)**: 309–314 (2003)
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First record of *Thalassius albocinctus* (Doleschall) (Araneae: Pisauridae) from India

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ABSTRACT: *Thalassius albocinctus* (Doleschall) is recorded from India for the first time and its female is redescribed and illustrated. © 2003 Association for Advancement of Entomology

INTRODUCTION

The genus Thalassius is a small genus of the family Pisauridae endemic to Oriental and Ethiopian regions. It is readily recognized from other Pisaurids by the presence of strongly recurved anterior eyes; clypeus beyond ocular quadrangle, eyes arranged in three rows, first row formed of anterior median eyes, second row formed of anterior lateral eyes, and third row formed of posterior median eyes and posterior lateral eyes; chelicerae with three retromarginal teeth; tibial apophysis of the pedipalp reduced; Epigynum with distinct lateral lobes and median septum. Except *Thalassius phipsoni* FOP Cambridge, 1898 (Pocock, 1900) no other species of this genus has so far been reported from India.

Thalaassius albocinctus (Doleschall), a beautiful species of this genus is reported from many South East Asian countries such as Myanmar, Philippines, Thailand, Malaysia, and Indonesia. *T. albocinctus* is first described by Doleschall in 1859 under the genus *Dolomedes*. Later *Triturius marginellus* described by Simon in 1884 was found to be synonymous with it. In 1885 Genus *Thalassius* was erected by Simon and the species is transferred to it. Many species like *Ctenus fimbriatus* described by Hasselt in 1890 and *Dolopoeus cinctus* and *Dolomedes albo-cinctus* described by Thorell in 1891 and 1892 were found to be synonymous with it. The specific name *Thalasius albocinctus* was first used by Thorell in his Spiders of Burma (1895). Later FOP Cambridge has described these species in many names such as *T. simoni* (1897), *T. doleschalli* (1897), *T. cinctus* (1897), *Dolopeous doleschalli* (1898), *D. simoni* (1898), and *D. albocinctus* in 1898. Similarly *T. mutilliatus* described by Strand (1913) is now considered synonymous to *T. albocinctus*. Most recent record of *T*

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albocinctus is from Singapore by Joseph (1989) and from Philippines by Barrion and Litsinger (1995). During the course of our investigation about the diversity of spiders in Ernakulam District we came across few specimens of this species. On the basis of these specimens *T. albocinctus* (Doleschall) is recorded and described from India.

METHODOLOGY

Spiders were collected from foliage while resting on the top of leaves with its four legs of each side placed together in two sets. They were collected by methods suggested by Tikader (1987). Collected spiders are preserved in 80% alcohol and studied by Stereomicroscope, Leica MS 5. All measurements are in mm taken with an eyepiece graticule. Epigyne is studied by clearing in 10% KOH. Status of the species is confirmed by comparing with descriptions and illustrations provided by Thorell (1895) and Barrion and Litsinger (1995).

Material examined: 2 ♀♀, Bhoothathankettu, Coll. Sunil Jose. K and Aby P. Varghese, 12.IX.2000, Habitat: Moist Deciduous forest.

Abbreviations used are as follows: AME = Anterior median eyes, ALE = Anterior lateral eye, PME = Posterior median eye, PLE = Posterior lateral eye, OQ = Ocular quadrangle, DVPR = Dorsal-ventral-prolateral-retrolateral.

TABLE 1. Length of leg and pedipalp segments

Leg	Femur	Patella	Tibia	Metatarsus	Tarsus	Total
I	12.10	4.00	10.50	9.50	4.50	40.60
II	12.20	4.35	12.20	11.25	5.35	45.35
III	9.50	3.50	8.50	8.80	4.00	34.30
IV	13.20	4.70	12.80	12.30	5.50	48.50
Pedipalp	5.10	1.35	2.45		3.55	12.45

RESULTS

Thalassius albocinctus (Doleschall) 1859

Female

(Fig. 1a–g)

General

Total length 20 mm, Cephalothorax 9 mm, Abdomen 10 mm. Cephalothorax blackish brown bordered by white lateral stripes. Abdomen blackish brown with white lateral stripes. Legs yellowish brown, long and clothed with hairs and spines, Leg measurements as in Table 1.

Distribution

Myanmar (Thorell, 1895); Philippines (Barrion and Litsinger, 1995); India (New record): Kerala: Bhoothathankettu, Ernakulam district.

Cephalothorax

Longer than wide, anterior end abruptly narrowed at ocular region. Cephalic region is slightly elevated in the middle. Dorsum clothed with minute pubescence. Mid dorsal area blackish brown with lateral sides bordered by white lateral stripes, a bluntly triangular yellowish patch below ocular region. Fovea longitudinal and long. Ocular region hairy. Eyes eight, both rows recurved, anterior row shorter and strongly recurved, posterior row longer. ALE small, almost half the size of AME. Eyes dark brown and encircled by black bases; PLE on black lateral tubercles, black bases of PLE extending slightly towards inside and touching the ALE. Ocular quadrangle square like, minutely wider at anterior end. Behind posterior eyes long black hairs present Eye distance: AE = 2.178; PE = 3.15. Eye separation: AME–AME = 0.29, AME–ALE = 0.254, PME–PME = 0.472, PME–PME = 0.617. Eye diameter AME = 0.435, PME = 0.363, ALE = 0.254, PLE = 0.413; AME and PME nearly equal in size. Clypeus broad, height more than two and half times the diameter of AME. Chelicerae reddish brown, hairy provided with boss, more than twice longer than wide with anterior end narrower. Promargin with three teeth; apical tooth smaller,

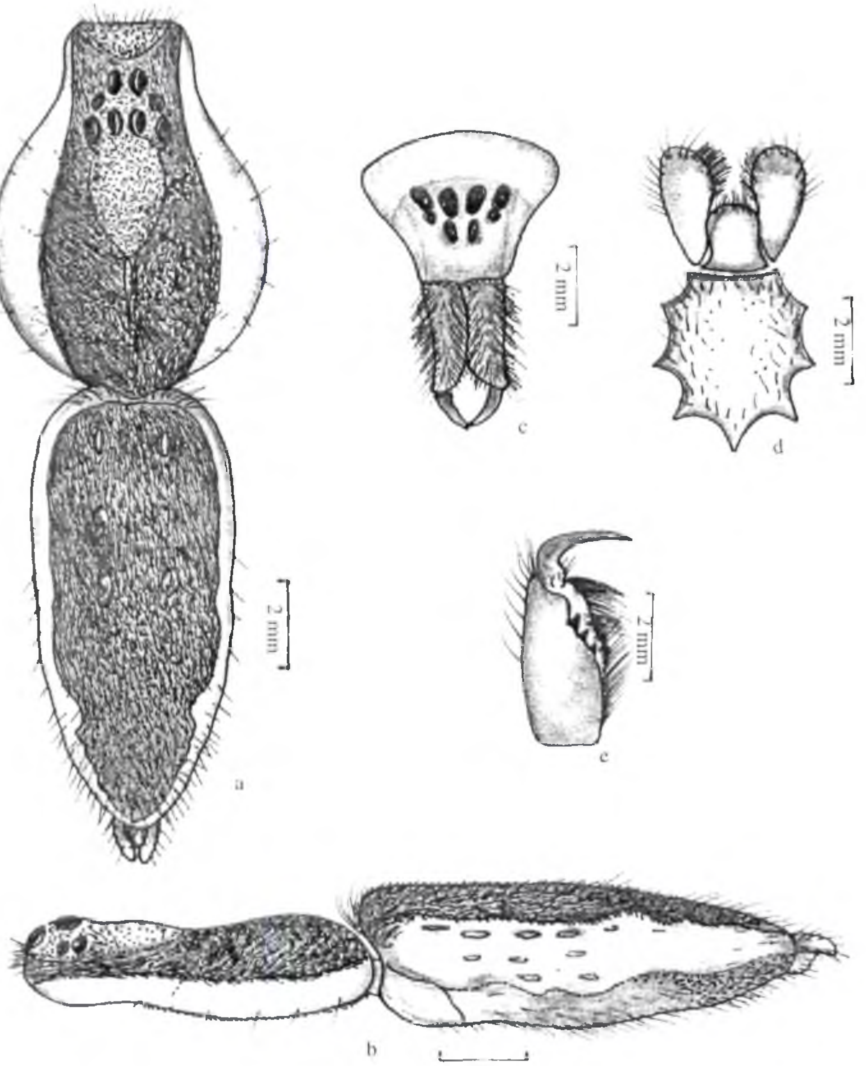

FIGURE 1. *T. albocinctus (Doleschall)* Female: (a) Dorsum with legs omitted, (b) Lateral View, (c) Frontal View, (d) Sternum with Maxillae and Labium (e) Chelicerae.

middle larger, basal slightly smaller than middle. Retromargin with three equal sized LARGER TEETH. Labium and maxillae similar in colour with chelicera but more lighter. Labium truncated at apex with a constriction at the base, anterior margin more yellowish, basal one third darker, scopulate at apex. Maxillae longer than broad, apical

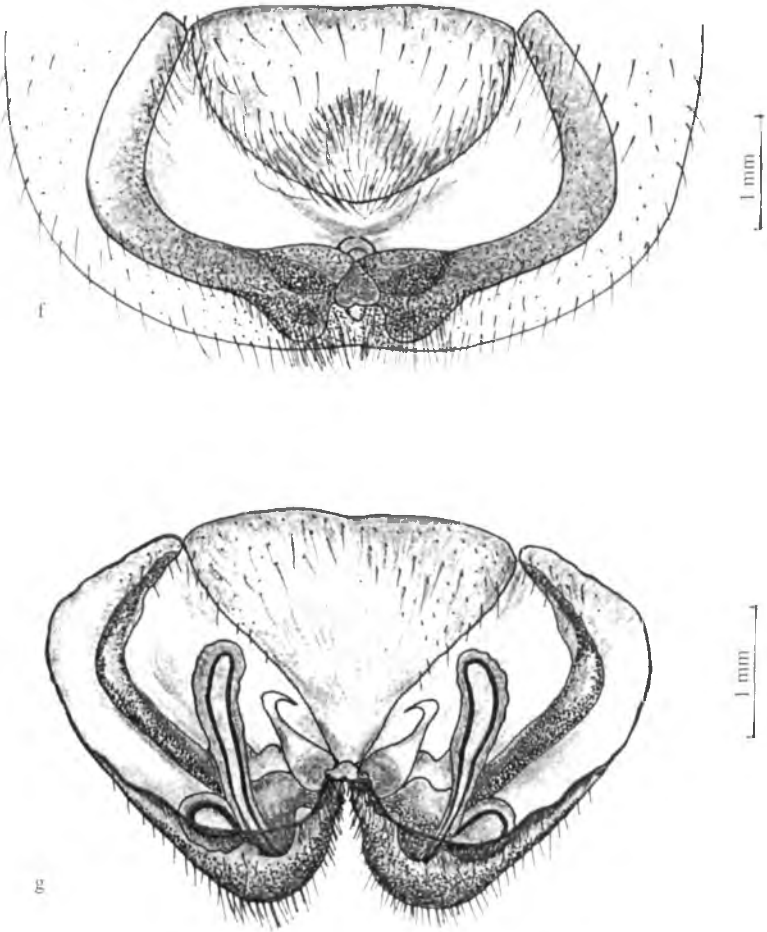

FIGURE 1. *T. albocinctus (Doleschall)* Female: (f) Epigynum, (g) Internal genitalia.

region bears scopulae. Sternum longer than broad, yellowish brown and hairy. Legs yellowish brown, long and clothed with hairs and spines. Tarsus three clawed, two superior claws bear nine teeth each, inferior claw with two teeth. Leg formula 4213. Leg spination formula: Tibia I = 2-8-2-2; II = 2-8-2-2; III = 1-8-3-2; IV = 1-8-2-2. Femur I = 3-0-5-5; II = 3-0-7-6; III = 3-0-5-5; IV = 3-0-4-3. Pedipalp similar in colour with legs, tarsal claws with four teeth. Male: Unknown.

Abdomen

Longer than wide, narrower posteriorly; basal half broader with anterior end truncated. Pedicel visible from above. Dorsal surface black with white lateral longitudinal stripes;

median black patch has a small inward notch in the posterior half. Dorsum flat uniformly covered with fine pubescence; in juveniles dorsum is provided with seven pairs of small white dots, only the anterior four pairs are visible in adults. Six pairs of sigilla present, posterior pair are less conspicuous. Ventrum with a broad triangular dark brown band, bordered by yellowish patches on lateral sides. Epigynum with posterior end of lateral lobes converging, anterior end diverging; anterior and posterior margin provided with dark brown hairs between lateral lobes. Internal genitalia with a blind tube projecting anteriorly in both lateral lobes as in Fig. 1g.

CONCLUSION

Identification

Cephalothorax and abdomen with white stripes along the lateral border; Abdomen with triangular shaped brown patch on the ventrum, dorsum decorated with 4–7 pairs of small white spots; Superior tarsal claws with nine teeth; Tarsal claws of pedipalp with four teeth; PLE = AME > PME > ALE. Leg spination: Femur I = 3-0-5-5, Femur IV = 3-0-4-3; Tibia I = 2-8-2-2, Tibia IV = 1-8-2-2. Epigynum with posterior end of club shaped lateral lobes converging and anterior ends diverging apically.

KEY TO INDIAN GENERA OF THALASSIUS

White stripes along the lateral margin of cephalothorax and abdomen...
... *T. albocinctus*.

White stripes separated from lateral margin by a space equaling its width...
... *T. phipsoni*.

ACKNOWLEDGEMENT

We thank Principal Rev. Fr. Joseph Poonely CMI for providing the laboratory facilities and for his keen interest in our work. Financial assistance received from KSCSTE is acknowledged.

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A new species and a key to Indian species of *Hierodula* Burmeister (Mantodea: Mantidae)

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ABSTRACT: A new species *Hierodula (Hierodula) keralensis* of Mantidae is described and illustrated. The species is closely allied to *Hierodula (Hierodula) membranacea* Burmeister.

KEYWORDS: Mantidae, *Hierodula*, new species, India

INTRODUCTION

The genus *Hierodula* was erected by Burmeister (1838) based on the type species *Hierodula membranacea*. Mukherjee & Ghosh (1995) reported 11 species from India. They are *Hierodula (Hierodula) assamensis* Mukherjee & Hazra, *Hierodula (Hierodula) beieri* Mukherjee & Hazra, *Hierodula (Hierodula) bipapilla* (Audinet Serville), *Hierodula (Hierodula) doveri* Chopard, *Hierodula (Hierodula) grandis* Saussure, *Hierodula (Hierodula) membranacea* (Burmeister), *Hierodula (Hierodula) nicobarica* Mukherjee & Hazra, *Hierodula (Hierodula) saussurei* Kirby, *Hierodula (Hierodula) tenuidentata* Saussure, *Hierodula (Hierodula) unimaculata* (Oliver) and *Hierodula (Hierodula) ventralis* Giglio-Tos.

In this paper a new species of *Hierodula (Hierodula)* namely *Hierodula(Hierodula) keralensis* sp. nov. from Attappadi, Kerala is described. A key to an Indian species is also provided.

MATERIALS AND METHOD

The specimen was collected from the leaf by hand picking. It was killed by using Ethyl acetate and pinned with insect pin of size 38 mm × 53 of No. 3. The observations were made using M3 Z Wild Stereozoom (Switzerland) and Leitz-Watzlar (Germany) microscopes. The figures were drawn using drawing tube of Wild M3Z stereozoom microscope and reduced.

*Corresponding author

Abbreviations

OOL = ocellocular distance; POL = postocellar distance; OD = Median ocellar diameter; DZCU = Department of Zoology, University of Calicut.

RESULTS

The Genus *Hierodula* Burmeister is divided into 2 subgenera

Key to Subgenera

Dialation of mesosoma not extending upto base ....
Hierodula(*Hierodula*) Giglio-Tos
-Dialation of mesosoma extending upto base ....
Hierodula. (*Rhombodera*) Giglio-Tos

Subgenus Hierodula (Hierodula) Giglio-Tos

There are 12 species reported from India, including the new species described here.

Key to Indian species of Hierodula (Hierodula)

1. Forecoxa with sharp saw-like marginal spines 2
- Forecoxa with obtuse, stout marginal spines 6

2. Fore coxal spines 15–20 in number 3
- Forecoxal spines less than 10 4

3. Clypeus broader than high; metatarsus 1.4× longer than all other tarsal segments together .... *H. (H.) keralensis* sp. nov.
- Clypeus higher than broad, metatarsus as long as all other tarsal segments together .... *(H.) membranacea* (Burmeister)

4. Fore coxa with 7–9 marginal spines, without any spinules among them 5
- Fore coxa with 5–6 marginal spines, with a few spinules among them ....
.... *H.(H.) unimaculata* (Olivier)
5. All internal spines of fore femur black at apex only ....
.... *H.(H.) nicobarica* Mukherjee
- First and third discoidal, first, fifth and last internal spines of fore femur entirely black .... *H. (H.) beieri* Mukherjee
6. Metazona shorter than forecoxa 7
- Metazona much longer than forecoxa 8

7. Prosternum with 2 black bands .... *H. (H.) assamensis* Mukherjee
- Prosternum without such bands .... *H. (H.) tenuidentata* Saussure

8. Forecoxa with 8–10 marginal spines; trochanter black at apex .... *H. (H.) grandis* Saussure
- Forecoxa with less than 8 marginal spines; trochanter not black at apex 9
9. Forecoxa with 2-3 marginal spines .... *H. (H.) bipapilla* (Audinet-Serville)
- Forecoxa with 4-7 marginal spines 10

10. Pro- and mesosternum with black markings 11
- Pro- and mesosternum without black markings but with two white spots .... *H. (H.) saussurei* Kirby

11. Pro- and mesosternum with oblique stripes .... *H. (H.) ventralis* Giglio-Tos
- Pro- and mesosternum with a median stripe and 4 round spots .... *H. (H.) doveri* Chopard

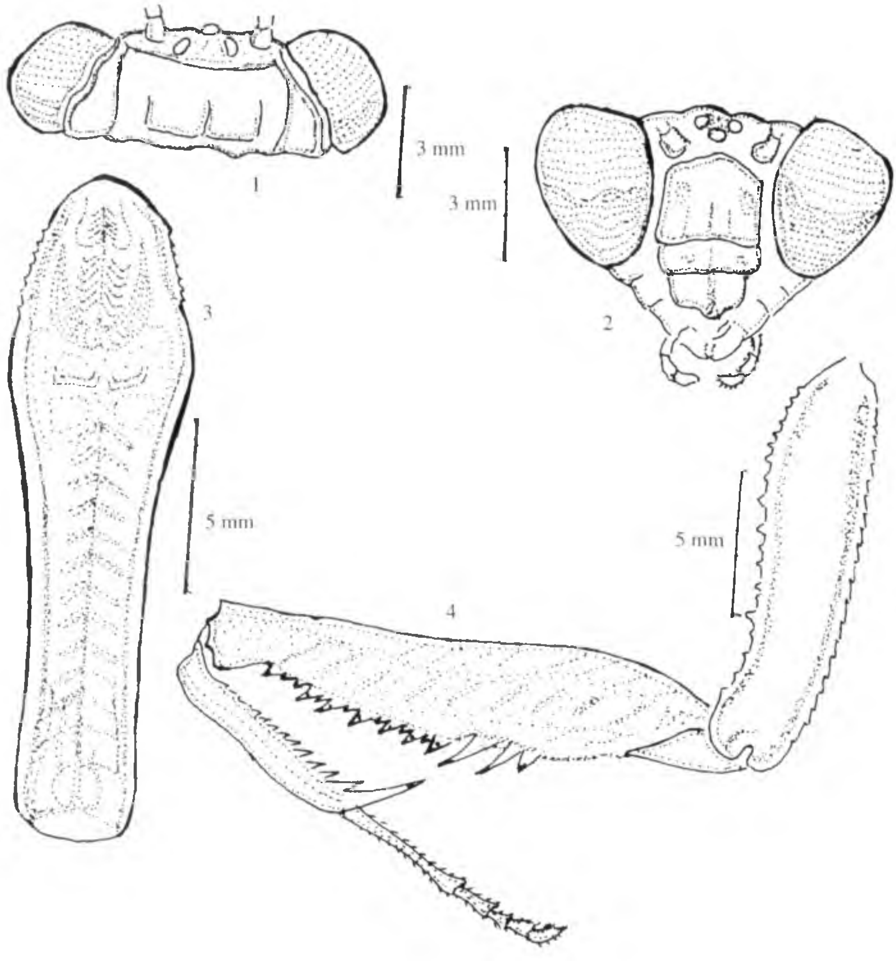
Hierodula (Hierodula) keralensis **sp. nov.**

Holotype

Male Body length 83 mm.

Colour

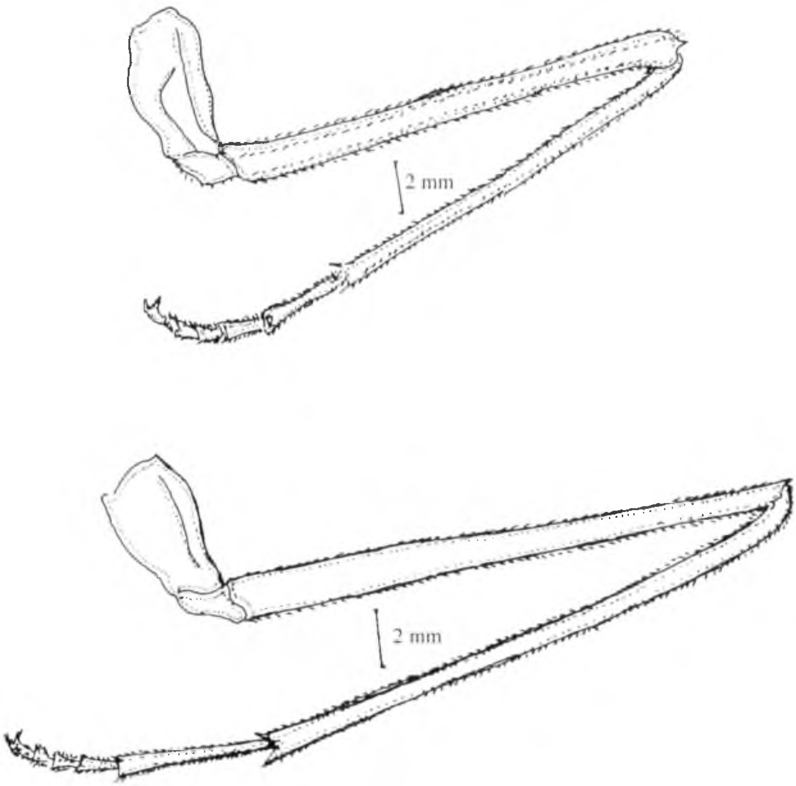
Light green with slight ferrugeneous prozonal border. Vertex moss green with faint black tinge; ocelli yellowish orange with black border; frontal sclerite moss green with brown tinge, clypeus and labrum bright moss green, without any black tinge; antennal scape and pedicel concolorous with frontal sclerite; flagella fuscous. Mesosoma: dirty greenish testaceous at middle; metazonal border ferrugeneous; posterio- lateral sides testaceous; sternum yellowish green with brown streak; postmesoternum with two black dots; forelegs concolorous with mesosoma, coxal spines yellowish green; trochanter moss green; all spines of forefemur and foretibia black at tips only, internal longer spines with a black dot at the middle, other than at tips; tibial claw green, tip testaceous to black; metatarsus and other tarsal segments green with black tips; middle and hind legs: coxa green to testaceous; femur completely testaceous, tibia greenish with yellow tinge; metatarsus and other tarsal segments dirty green; forewing with costal area moss green and opaque discoidal area light green, semihyaline; stigma yellow; veins light green. Metasoma testaceous with green tinge.



FIGURES 1–4: *Hierodula (Hierodula) keralensis*: 1. Head Dorsal view; 2. Head Ventral view; 3. Mesosoma; 4. Fore leg.

Head

Triangular, 1.2× wider than high; vertex smooth, lateral lobes more prominent; eyes globular laterally, oval ventrally, emarginate; ocelli large, prominent, slightly elevated; POL : OD : OOL = 1 : 1 : 2; antenna filiform, slender, non ciliated; frontal sclerite pentagonal, almost as wide as high, superior margin slightly angular, disc not much depressed, bicarinate, inferiorly weakly arched and lateral corners bluntly conical; clypeus transverse, nearly 2 × wider than high, with 2 bosses; labrum transverse.



FIGURES 5 & 6: *Hierodula (Hierodula) keralensis*: 5. Middle leg; 6. Hind leg.

Mesosoma

Elongated, longer than forecoxa, robust; supra coxal dialation oval, 3.6× longer than wide at supra coxal diation; prozona bluntly spatulate with denticulated margin; disc with carina; metazona 2.5× longer than prozona; carina not well pronounced as in *H. (H.) membranacea*, inferiorly slightly arched Forelegs: stouter than in *H. (H.) membranacea*, coxa with seventeen strong saw-like spines; internal apical lobes contiguous, inferior margin serrated; femur slightly longer than coxa and 3× longer than tibia, with 4 external, 4 discoidal and 8 longer and 7 shorter internal spines; tibia with 10 external and 11 internal spines; metatarsus slightly shorter than tibia and 1.4× longer than all other tarsal segments together. Middle and hind legs: slender, coxa shorter, femur and tibia almost equal in length; tibia more slender than femur, metatarsus 1.3× longer than other tarsal segments together. Wings: both wings longer than metasoma; forewing with costal are broad, opaque, discoidal area semihyaline; anterior radial vein bifurcates at middle and branches, discoidal vein bifurcates twice; hind wing hyaline; posterior radial vein bifurcates thrice.

Metasoma

A little flat posteriorly; supra anal plate tranverse; cerci short, slender.

Material examined

Holotype: INDIA, Kerala, Attappadi, 1-xii-2000; Vyjayandi, M.C (DZCU).

Biology

Unknown.

Habitat

Seen among leaves of undisturbed areas.

DISCUSSION

This species *Hierodula (Hierodula) keralensis* sp. nov. is closely realted to *Hierodula (Hierodula) membranacea* (Burmeister) in the following characters: 1. colour, size and general appearance of the body. 2. Presence of more than fifteen superior marginal spines on the forecoxa 3. Frontal sclerite almost as high as wide. This species *Hierodula (Hierodula) keralensis* sp. nov. differs from *Hierodula (Hierodula) membranacea* (Burmeister) in the following characters: 1. Clypeus twice wide than high in *H. (H.) keralensis* sp. nov. (clypeus as wide as high in *H. (H.) membrancea*) 2. mesosoma, coxa and femur of forelegs robust and shorter; metazona 2.5× longer than prozona in *H. (H.) keralensis* sp. nov. (mesosoma, coxa and femur of forelegs slender; metazona 3× longer than prozona *H. (H.) keralensis* sp. nov., (mesosomal carina well pronounced in *H (H) membranacea*) 4. Foretibia: foremetatarsus 4:3 in *H. (H.) keralensis* sp. nov. (5:3 in *H. (H.) membranacea*) 5. metatarsus: other tarsal segments 3:2 in *H. (H.) keralensis* sp. nov. (the ratio is 1:1 in *H. (H.) membranacea*) 6. Prozonal outer margin denticulated in *H. (H.) keralensis* sp. nov.) (not denticulated in *H. (H.) membranacea*).

ACKNOWLEDGEMENTS

We are grateful to University of Calicut for the facilities provided. The first author is grateful to the University Grants Commission New Delhi for the Fellowship under Faculty Improvement Programme.

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ENTOMON **28(4)**: 321–327 (2003)
Article No. ent.28406

New Lynx spiders, *Oxyopes* Latreille (Oxyopidae) from Buxa Tiger Reserve, Jalpaiguri, West Bengal

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ABSTRACT: Two new species of the genus *Oxyopes* Latreille (Oxyopidae), *O. longispinus* and *O. rajai* are reported from Buxa Tiger Reserve, Jalpaiguri, West Bengal. With these there are altogether 44 *Oxyopes* species in India.

KEYWORDS: New spiders, *Oxyopes*, Oxyopidae, West Bengal, Jalpaiguri, Buxa Tiger Reserve

INTRODUCTION

Genus *Oxyopes* Latreille (Oxyopidae) of India has recently been reviewed by Gajbe (1999). He (op.cit.) considered 20 species within the genus. However, there are 22 more species known from India (Platnick, 2003). It seems that Gajbe (1999) in his article did not consider any of those.

In our effort to deal with *Oxyopes* species recently recorded (March, 2001) from Buxa Tiger Reserve, Jalpaiguri, West Bengal, we are inclined to recognize 2 more new species namely, *O. longispinus* and *O. rajai*. These are described and illustrated. With these Indian *Oxyopes* species stands at 44.

The types of the recorded species are deposited in the collection of Entomology Laboratory, Department of Zoology, University of Calcutta.

MATERIALS AND METHODS

Collection and preservation of the spider samples were done following Tikader (1987). The materials were studied using a sterezoom binocular microscope, model Zeiss SV8. All the measurements are in millimeters, made with an eyepiece graticule.

*Corresponding author.

TABLE 1. Length of legs ♀ holotype of *Oxyopes longispinus* n. sp. (in mm)

Leg	Femur	Patella & Tibia	Metatarsus	Tarsus	Total
I	3.4/3.5	4.0/4.0	2.8/2.7	1.5/1.5	11.7/11.7
II	3.4/3.6	4.0/4.1	4.6/4.6	1.4/1.4	13.4/13.7
III	3.8/3.8	3.8/3.6	3.4/3.4	1.6/1.7	12.6/12.5
IV	4.6/4.5	5.0/5.1	4.0/4.1	2.0/2.1	15.6/15.8

Male unknown.

Holotype

Female: Total length 11.15; carapace length 4.45, width 2.55; abdominal length 6.20, width 2.60; legs as in Table 1.

Diagnosis

Ocular quad medially with a pair of long brown spiny hairs projecting forward; posteromedian eyes largest, ringed with eye lashes.

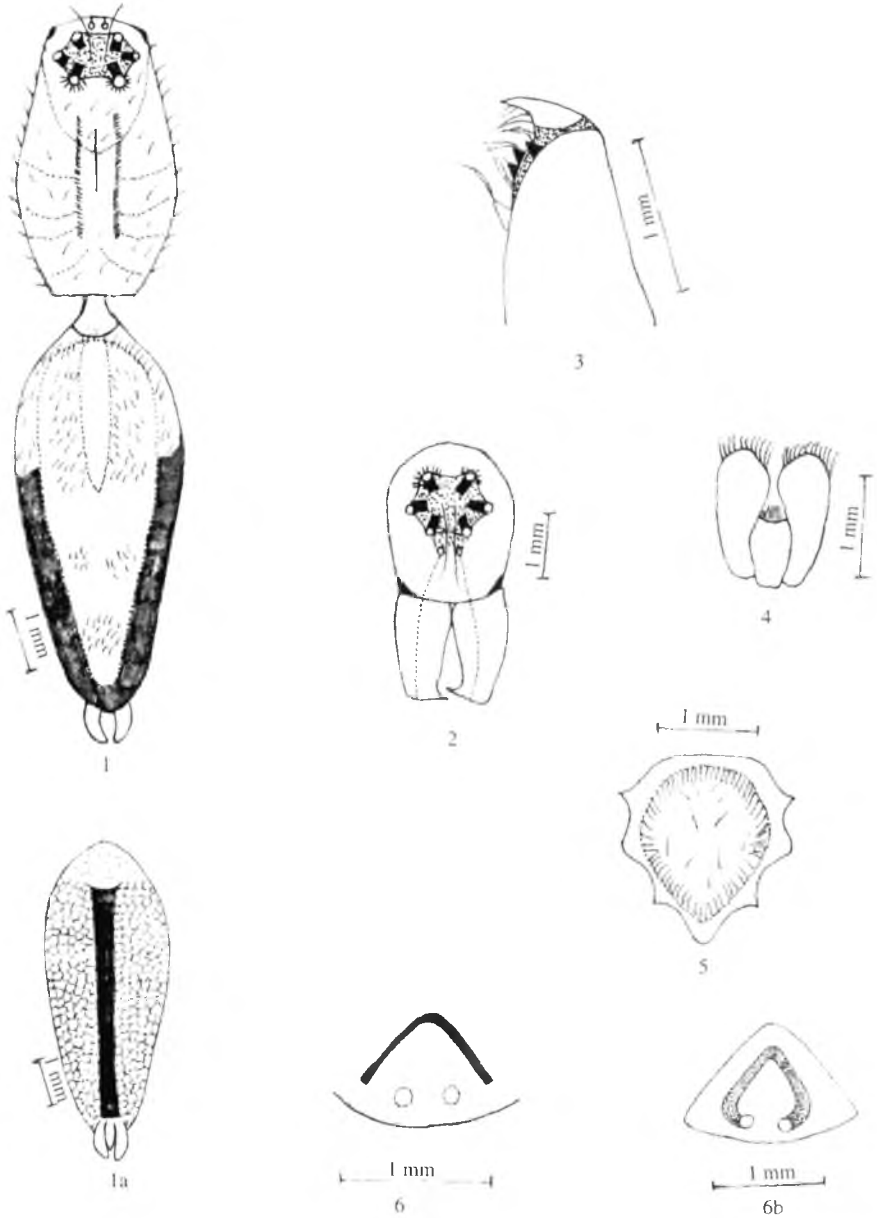
Carapace

Cephalothorax (Fig. 1) brown, medially paler, with a longitudinal fovea, longer than wide, oval, slightly narrowing in front, cephalic region little raised, with 2 faint longitudinal parallel brown lines, radii indistinct. Eyes pearly white, basally marked by black, equidistantly placed, anterior row strongly recurved, posterior row procurved, laterals close, ocular quad squarish, medially with a pair of long brown spiny hairs projecting forward, posteromedians largest, ringed with eye lashes. Clypeus broad elongate, anterolateral angles black, medially with a pair of black lines extending from each of the anteromedian eye to near to base of cheliceral fang as in Fig. 2. Chelicerae (Fig. 3) pale yellow, robust, inner margin with 1 and outer margin with 2 teeth, the latter with long hairs, fang red brown, short, robust, broad, acute. Maxillae pale yellow, labium little darker, both anteriorly scopulate (Fig. 4). Sternum (Fig. 5) pale yellow, rather globose, with long and short hairs. Legs pale yellow, long, stout, with hairs and spines, femora with a ventral longitudinal black line; leg formula 4231.

Abdomen

Pale yellow, basally with a lanceolate patch, laterally with black bands converging towards apex, clothed with reddish hairs and white pubescence, long, cylindrical, narrowing towards apex (Fig. 1). Venter (Fig. 1a) medially with a black broad longitudinal band extending from epigastric furrow to the base of spinnerets, on either side with white reticulations. Epigyne and internal genitalia as in Figs 6a and b.

Oxyopes longispinus n.sp.



FIGURES 1–6 *Oxyopes longispinus* n. sp., female holotype: 1. Whole body; 1a. Abdomen: Venter; 2. Cephalic region showing the eye pattern and black lines from anteriormost eyes upto the fangs; 3. Chelicerae; 4. Maxillae and labium; 5. Sternum; 6a. Epigynum; 6b. Internal genitalia.

Materials examined

Holotype, Female, Rajabhatkhawa, Buxa Tiger Reserve, Jalpaiguri, West Bengal, India, 8.III.2001. Coll. S. Saha.

Distribution

India: West Bengal, Jalpaiguri (known only from the type locality).

Remarks

None of the Indian congeners show affinity with the present species *Oxyopes longispinus* n.sp. Species appears distinct in having a pair of long brown hairs on the ocular quad, posteromedian eyes basally with a ring of eye lashes, rather circular sternum, reddish haris on abdominal dorsum and a typical epigyne and internal genitalia.

Etymology

The species name is derived from the long spiny hairs present within the ocular quad.

Holotype

Total length 14.00; carapace length 4.25, width 3.35; abdominal length 8.85, width 4.00; legs as in Table 2.

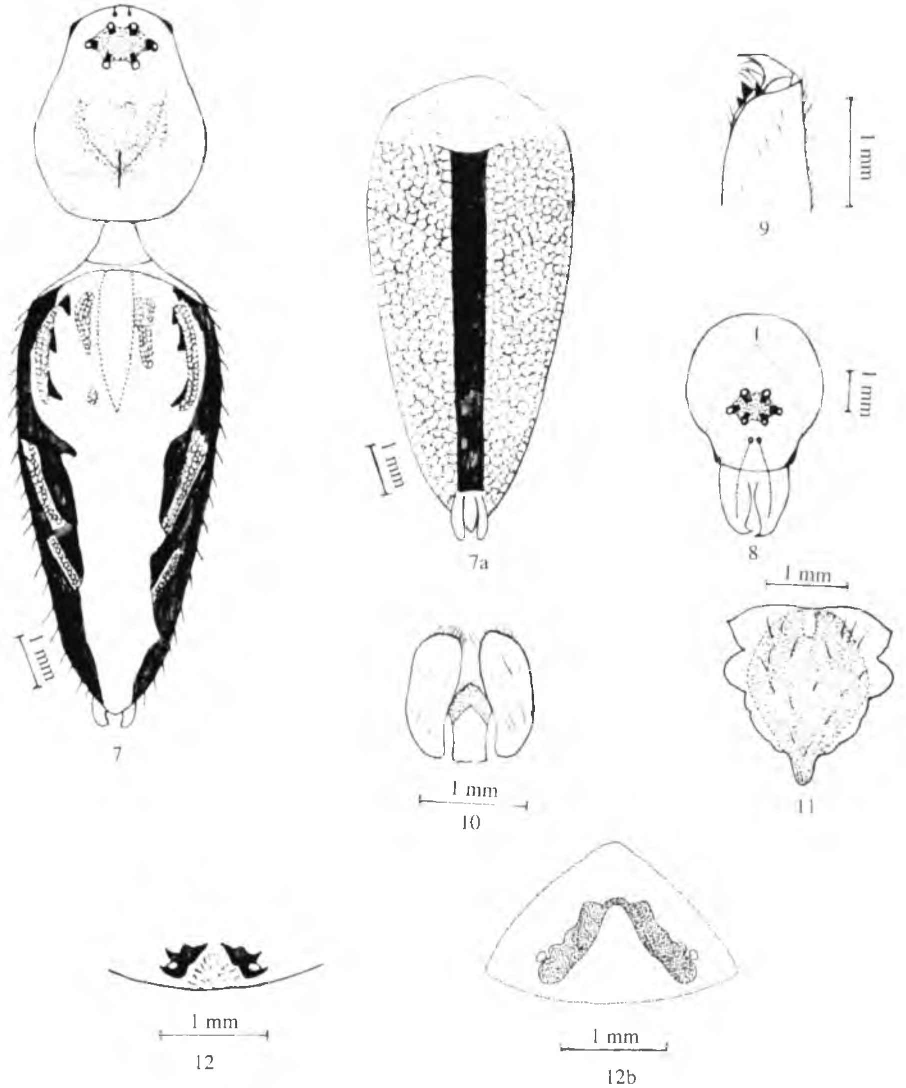
Diagnosis

Sternum isolateral, widened little before the middle, posteriorly narrowed and produced; carapace with 4 longitudinal bands and a deep brown patch.

Carapace

Cephalothorax (Fig. 7) brown, medially paler, longer than wide, cephalic region little raised, median longitudinal fovea distinct, with fine hairs. Eyes black, encircled by black patch, equidistantly placed, anterior row strongly recurved, posterior row procurved, anteromedians smallest, ocular quad elongately rectangular, blackish. Clypeus long, broad, anterolateral angles black, medially with 2 black lines extending from each of the anteromedian eye to near the base of cheliceral fang as in Fig. 8. Chelicerae (Fig. 9) pale yellow, robust, inner margin with 1 and outer margin with 2 teeth, the latter with long brown hairs, fang pale brown, short, stout, acute. Maxillae pale brown, labium apically darker, little elongate, both apically scopulate (Fig. 10). Sternum (Fig. 11) pale yellow, broadly triangular, posteriorly produced, with few long brown hairs. Legs long, stout, with brown hairs and spines, femora ventrally with a conspicuous longitudinal black line; leg formula 4321.

Oxyopes rajai n. sp.



FIGURES 7–12: *Oxyopes rajai* n. sp.: 7. Whole body; 7a. Abdomen: Venter; 8. Cephalic region showing the eye pattern and black lines from anteriormost eyes upto the fangs; 9. Chelicerae; 10. Maxillae and labium; 11. Sternum; 12a. Epigynum; 12b. Internal genitalia.

Abdomen

Pale yellow, basally with a lanceolate patch, laterally with black stripes, rest with few patches of white reticulations as in Fig. 7, long, cylindrical, narrowing behind, clothed

TABLE 2. Length of legs ♀ holotype of *Oxyopes rajai* n. sp. (in mm)

Leg	Femur	Patella & Tibia	Metatarsus	Tarsus	Total
I	3.4/3.5	4.2/4.0	3.0/3.1	2.1/2.0	12.7/12.6
II	3.4/3.6	5.0/4.9	3.2/3.3	1.4/1.4	13.0/13.2
III	3.4/3.5	5.0/5.0	3.2/3.0	2.1/2.1	13.7/13.6
IV	3.6/3.4	5.0/5.1	4.5/4.5	1.6/1.8	14.7/14.8

Male unknown.

with fine hairs. Venter (Fig. 7a) brown, with median longitudinal broad black band extending from epigastric furrow to near the base of spinnerets, on either side with white reticulations. Epigyne and internal genitalia as in Figs 12a and b.

Material examined

Holotype, Female, Rajabhatkhawa, Buxa Tiger Reserve, Jalpaiguri, West Bengal, India, 8.III.2001, Coll. D. Raychaudhuri.

Distribution

India, West Bengal, Jalpaiguri (known only from the type locality).

Remarks

The present species seems close to *bharatae/shwetae/sikkimensis/sitae* group (Gajbe, 1999). However, it stands distinct in not having any spatulate hair, 4 longitudinal bands and deep brown patch on carapace. On the otherhand it has a characteristics sternum, labium, a typical epigyne and internal genitalia. The species in question may also be related to *O. birmanicus* Thorell (Sherriff, 1951; Tikader and Biswas, 1981; Platnick, 2003) because of gross similarity in the epigyne. But a critical assessment of the epigyne of the present species reveals wide difference with that of *O. birmanicus*. Besides, the other points of differences are as follows:

1. fang uniformly pale brown vs. white distally
2. sternum medially dark vs. sides darker
3. leg formula 4321 vs. 1243
4. femora with 1 ventral black line vs. 2 black lines
5. abdomen dorsally with a lanceolate patch vs. any such; ventrally with 1 broad brown band vs. several lines.

The species is therefore described as new to science.

Etymology

The name is derived from the type locality.

ACKNOWLEDGEMENTS

We thank the authorities of Buxa Tiger Reserve and the Head of the Department of Zoology, University of Calcutta for kindly permitting us to carry out the work.

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Taxonomic studies on the genus *Anarsia* Zeller (Lepidoptera: Gelechiidae) from Siwaliks in India

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ABSTRACT: Ten species i.e., *Anarsia tegumentus* sp. nov., *A. patulella* (Walker), *A. valvata* sp. nov., *A. renukansis* sp. nov., *A. didymopa* Meyrick, *A. parkae* sp. nov., *A. tanyharensis* sp. nov., *A. triglypta* Meyrick, *A. veruta* Meyrick and *A. reciproca* Meyrick collected from North-Western Siwaliks have been taxonomically dealt with. A dichotomous key for their interspecific descrimination has been prepared. Besides complete description of new species, an illustrated account of the genitalia of already known species has also been furnished.

KEYWORDS: *Anarsia, tegumentus, patulella, valvata, renukaensis, didymopa, parkae, tanyharensis, triglypta, veruta, reciproca*, genitalia

INTRODUCTION

Workers such as Meyrick (1925), Park (1995), Park and Ponomarenko (1996a,b,c) and Ueda (1997) have worked on the genus *Anarsia* Zeller from certain parts of the globe. As such, this genus occupies a particular position in the family Gelechiidae, owing to characters such as sexual dimorphism in the labial palpi, modified scales and long sclerotization on the valvae and asymmetrical genitalia of both the sexes (Park and Ponomarenko, 1996c). While undertaking a project on moths, authors have collected *Anarsia* complex comprising one hundred and twenty-three individuals from certain localities in Siwaliks in North-West India. Due to cryptic maculation, it was realised that this complex can be authentically sorted out only after observing the genitalic characters of individuals representing various biological species. Accordingly, an examination of male genitalia of thirty-three individuals and female genitalia of sixteen individuals has been carried out, which led to an inference that the entire complex contains ten species i.e., *Anarsia tegumentus* sp. nov., *A. patulella* (Walker), *A. valvata* sp. nov., *A. renukansis* sp. nov., *A. didymopa* Meyrick, *A. parkae* sp. nov., *A. tanyharensis* sp. nov., *A. triglypta* Meyrick, *A. veruta* Meyrick and *A. reciproca* Meyrick (Meyrick, 1912–1916, 1916–1923, 1923–1930, 1930–1936). An account of

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the genus *Anarsia* with a key for identification of species collected in this study along with species descriptions is given below.

OBSERVATIONS

Genus *Anarsia* Zeller

Anarsia Zeller, 1839, *Isis, Leipzing*: 190
Ananarsia Amsel, 1959, *Stuttg, Beitr. Naturk,* **28**: 32. Type-species: *Anarsia lineatella* Zeller, 1839, *Isis, Leipzing*: 190.
Type-species: *Tinea spartiella* Schrank, 1802, *Fauna Boica*, **2**(2): 104, by subsequent designation: Meyrick, 1925, In Wytsman, *Genera Insect.,* **184**: 153.

Anarsia tegumentus **sp. nov.**

Male

Alar expanse: 11 mm. Vertex and frons covered with light grey scales; labial palpus long, upturned, second segment with light grey scales, the latter arranged subtriangularly, third segment relatively reduced in male, third segment long, acute, greyish black in female; antenna filiform, less than 3/4th length of the forewing, grey with black band alternatively; thorax fuscous in colour; forewing elongate, light grey scaled with black shades, costa slightly convex, apex acute, termen margin oblique, tornus ill defined, anal margin convex, costa with one small black bloach at middle, many black small lines on the costa and discal cell, termen with cilia light grey, apices white in colour; hindwing deep grey scaled, somewhat quadrate, costa convex at the base to 2/3rd, apex subacute, termen curved at middle, tornus poorly defined, anal margin straight, convex basally, anal and termen margin with cilia deep grey in colour; prothoracic and mesothoracic legs fuscous in colour, metathoracic leg light fuscous, small grey hair on hind tibia.

Wing venation (Plate 1, Figs B–C)

Forewing with Sc join beyond middle of costa, pterotigma between costa and Sc ending at R_1, which arise at middle of discal cell, R_2 nearer to R_3 than R_1, R_4 and R_5 long stalked, R_5 to costa, M_1 nearer to R_5 than M_2, M_2 and M_3, parallel, free, M_3 and CuA_1 connate, CuA_1 and CuA_2 free, discal cell closed, 1A and 2A forked basally; 3A absent; hindwing with $Sc+R_1$ arising from base of the cell, ending at middle of costa, $Rs+M_1$ stalked, arising at angle of cell, M_2 at middle of discal cell, free, M_3 and CuA_1 connate prior to posterior angle of cell, M_3 nearer to CuA_1 than M_2, CuA_2 arising near middle of discal cell, CuP vestigial, visible at near anal margin, 1A+2A short forked at base, 3A straight.

Male genitalia (Plate 1, Figs D–F)

Uncus straight, slit-like; a pair of socii large, somewhat rounded, heavily sclerotized; tegumen long, chimni-like, longer than valvae, dilated at base and middle, wall heavily

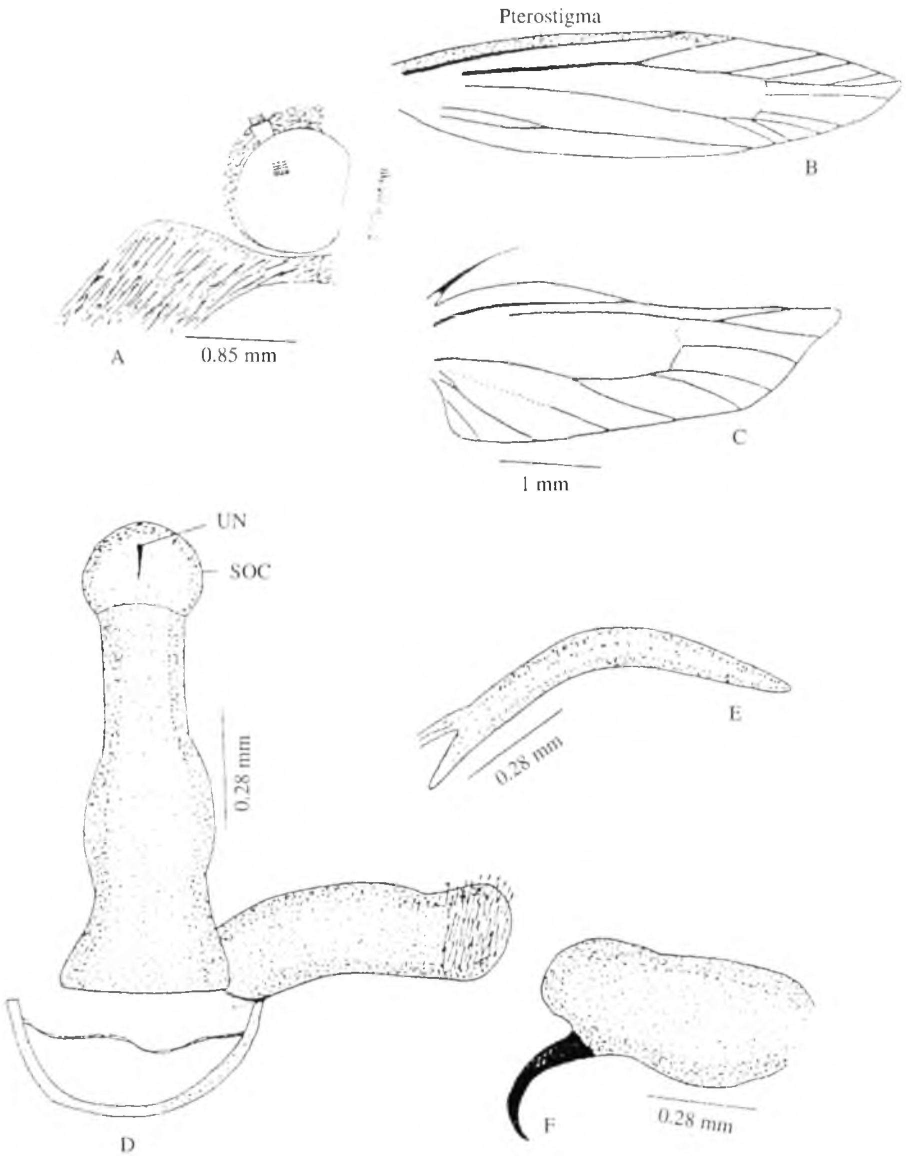


PLATE 1. *Anarsia tegumentus* sp. nov.: Figures: (A) Labial palpus male; (B) Forewing venation; (C) Hindwing venation; (D) Male genitalia : ventral view; (E) Aedeagus; (F) Left valva : ventral view.

sclerotized; vinculum U-shaped, narrower; saccus absent; juxta slit-like, weak; valvae asymmetrical, right valva small, almost equally broader, costal margin slightly convex, sacculus margin slightly concave at middle, weakly sclerotized, cucullus bearing short

stalked modified scales on the inner surface, margin convex dorso-distally, rounded apex, almost straight ventro-distally; left valva small, costal margin convex, sacculus margin convex at middle, cucullus margin convex dorso-distally, rounded apically, with a hook-like moderately long process ventro-distally; aedeagus long, bent at middle, apex almost pointed, coecum small, apex pointed; vesica without cornutus.

Female genitalia

Not studied.

Material examined

Holotype: Uttaranchal: Dist. Dehradun, FRI Dehradun, 700 m, 2.vi.1998, 1♂.

Paratypes: Uttaranchal: Dist. Dehradun, FRI Dehradun, 700 m, 2.vi.1998, 2♂♂.

Larval host plant

Unknown.

Remarks

In terms of maculation, *Anarsia tegumentus* sp. nov. is somewhat allied to *A. didymopa* Meyrick. However, the differences in the structures of their male genitalia facilitate their differentiation. For instance, the tegumen is highly specialized and appears like a 'chimni' in *tegumentus* sp. nov. which is not so in *didymopa* Meyrick. Besides, the uncus is slit-like in the former and triangular in the latter species. Moreover, there is hook-like moderately long process present in the cucullus region of the left valva in *tegumentus* sp. nov. and the same is missing in *didymopa* Meyrick.

Etymology

The name of the species as *Anarsia tegumentus* sp. nov. is derived from specialized tegumen in the male genitalia.

***Anarsia patulella* (Walker)**

Gelechia patulella Walker, 1864, *List Specimens lepid. Insects Colln. Br. Mus.*, **29**, p. 635.

Male genitalia (Plate 2, Figs A–C)

Uncus triangular in shape, broad at base, apex pointed; a pair of socii present, almost rounded, extended distally, bearing long dense hair; gnathos absent; tegumen elongated, longer than valvae, wall heavily sclerotized, slightly dilated at the middle and base; vinculum U-shaped, rather broader; saccus absent; juxta slit-like; valvae asymmetrical, right valvae leaf-like, somewhat subtrapezoidal, costal margin almost

straight, sacculus margin convex at base then concave, cucullus bearing modified scales on inner surface, long stalked, margin straight dorso-distally, apically spiny, slightly concave ventro-distally; left valva leaf-like, subtrapezoidal, costal margin almost straight, sacculus convex, bearing small membraneous spinous lobes and a spine on the ventral margin, cucullus with modified scales on inner surface, almost straight dorso-distally, spiny apically, ventro-distally concave; aedeagus small, almost straight, pointed at the apex, coecum present, pointed; vesica lacking cornutus.

Female genitalia (Plate 2, Fig. D)

Papillae anales small and wide, rounded, sparsely setose; anterior apophyses small, rod-like, broad at base, posterior apophyses long and thin, posterior apophyses longer than anterior apophyses; ostium bursae narrow, funnel-like; ductus bursae comparatively smaller, thin, slightly broad at middle, coiled near corpus bursae; ductus seminalis arising from the junction of the corpus bursae; corpus bursae large, subovate in shape, slightly sclerotized at base; a crescent shaped signum present.

Material examined

Uttaranchal: Dist. Dehradun, FRI Dehradun, 700 m, 3.iv.1999, 1♂.21.iv.1999, 1♂; 23.iv.1999, 15♂♂, 8♀♀; 25.iv.1999, 3♂♂, 3♀♀; 23.vi.1999, 1♂; 17.iv.2000, 1♀; 18.iv.2002, 2♂♂.

Distribution

India, Thailand, Sri Lanka, Taiwa and Australia (Park and Ponomarenko, 1996).

Larval host plant

Unknown.

Remarks

While reporting *Anarsia patul lla* (Walker) as a new record form Taiwan, Park (1995) has mentioned that this species occurs almost throughout the Oriental region, including the Southern part ı China. She has mentioned that the valvae in the male genitalia show certain variations but no such variation has been recorded in the presently dissected eight specimens. Moreover, all the main genitalic structures broadly conform to the figure give by her. Rather, on the basis of an examination of the male genitalia, it has been inferred that individuals showing variations in maculation are conspecific. Park and Ponomarenko (1996a) have reported it for the first time from Thailand. The species has already been reported from India without any indication about its precise .ocality/ies (Gaede, 1937, Park, *loc. cit.*). However, it is very common in Doon Valley Uttaranchal) from where a large sample comprising thirty-five individuals has presen..y been examined.

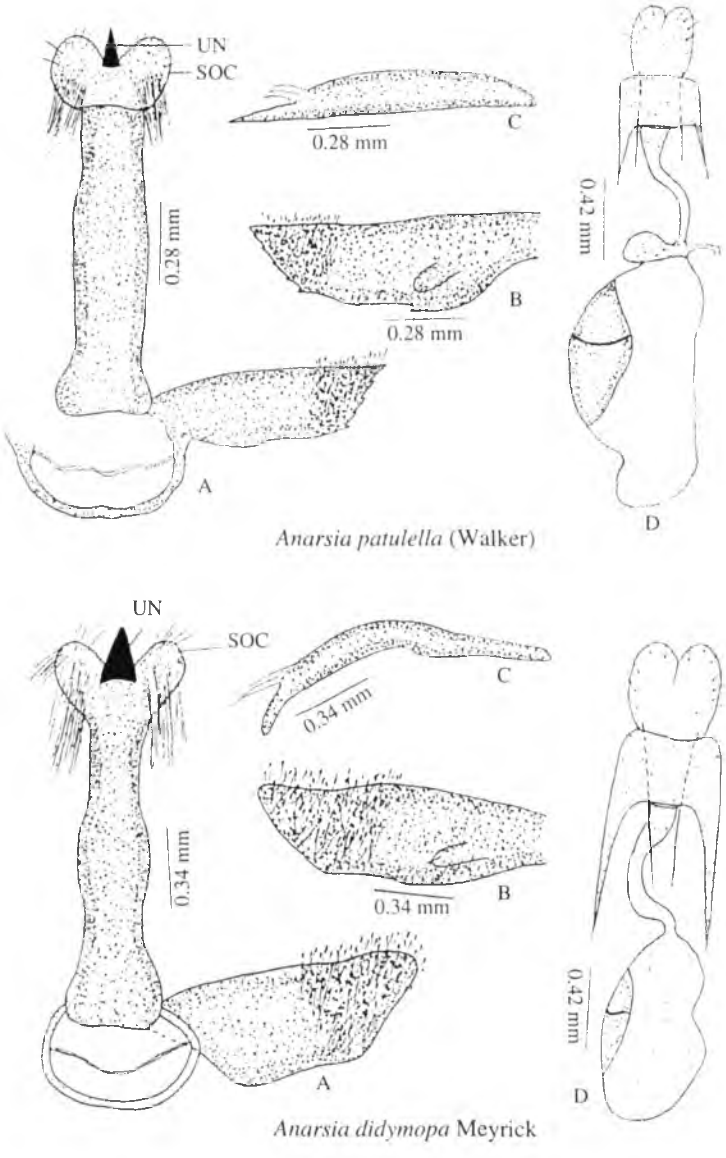


PLATE 2. *Anarsia patulella* (Walker): Figures: (A) Male genitalia: ventral view; (B) Left valva : ventral view (C) Aedeagus; (D) Female genitalia : ventral view.

Anarsia didymopa (Meyrick): Figures: (A) Male genitalia: ventral view; (B) Left valva : ventral view (C) Aedeagus; (D) Female genitalia : ventral view.

Anarsia valvata **sp. nov.**

Male and female

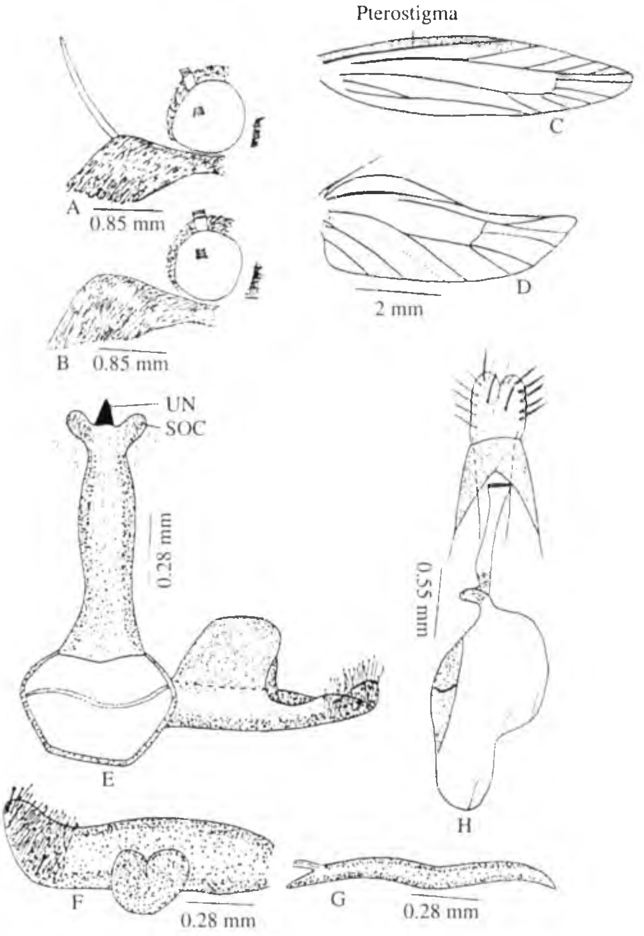
Alar expanse: 15 mm. Vertex covererd with grey scales; frons decorated with light grey scales; labial palpus long, upturned, second segment with long greyish black scales, the latter arranged subtriangularly, third segment relatively reduced in male, female with third segment long and acute, greyish black in colour; antenna filiform, smaller than 3/4th length of the forewing, grey and black ring alternatively; thorax fuscous in colour; forewing light grey scaled, costal margin slightly arched, apex subacute, termen margin oblique, tornus poorly defined, anal margin convex, two crescent shaped black spots on the 2/5th and 3/5th of costa, many small black spots on the upper surface of forewing, termen margin with cilia greyish black with white apices; hind wing deep grey scaled, somewhat quadrate, costa convex from base to 2/3rd then almost straight, apex acute, termen margin obtuse, tornus ill defined, anal margin sightly convex at middle, anal and termen margin with cilia deep grey in colour; prothoracic and mesothoracic legs fuscous in colour, metathoracic leg grey, hind tibia blackish grey with small grey hair.

Wing venation (Plate 3, Figs C–D)

Forewing with Sc ending beyond middle of costa, pterostigma between Sc and wing margin ending at R_1, R_1 arising at middle of discal cell, R_1, R_2, R_3, free, R_2, closer to R_3, than R_1, R_4+R_5 short stalked, R_5 to costa, M_1 free, nearer to R_5, than M_2, CuA_1 and CuA_2 free, CuA_1 closer to M_3 than CuA_2, discal cell closed, 1A+2A forked at base, ending near to CuA_2, 3A absent; hindwing with Sc+R_1 arising at base, ending beyond middle of costa, Rs+M_1 short stalked, M_2 free, nearer to M_1 than M_3, M_3 and CuA_1 connate, CuA_1 arising before middle of discal cell, free, CuP vestigial, 1A+2A forked at base, 3A straight.

Male genitalia (Plate 3, Figs E–G)

Uncus triangular in shape, broader at base, apex pointed; a pair of socii present, small, extended distally, bearing dense hair; gnathos absent; tegument elongate, longer than valvae, wall well sclerotized, slightly dilated at base and at middle; vinculum U-shaped, weakly sclerotized; saccus absent; juxta slit-like, weak; valvae asymmetrical, right valva elongate, costal margin bearing a large, rectangular flap-like structure join the sacculus and cucullus, costal margin almost straight, sacculus margin almost straight, cucullus with short stalked modified scales on the inner surface, dorso-distally slightly concave, rounded apically, convex ventro-distally; left valva elongate, broader at base and apex, costa straight upto 2/3rd from base then concave, sacculus basally convex then straight, bearing a large sclerotized mambranous lobe at middle, cucullus bearing short stalked modified scales on the inner surface, convex dorsally, apex rounded, convex ventrally; aedeagus long, almost equal to the length of valvae, slightly bent at middle, apex pointed, coecum small, acute apex; vesica lacking cornutus.



Anarsia valvata sp. nov.

PLATE 3. *Anarsia valvata* sp. nov.: Figures: (A) Labial palpus female; (B) Labial palpus male, (C) Forewing venation; (D) Hindwing venatin; (E) Male gentalia : venitral view; (F) Left valva : ventral view; (G) Aedeagus; (H) Female genitalia : ventral view.

Female genitalia (Plate 3, Fig. H)

Papillae anales moderately broader, almost rounded, sparsely setose; anterior apophyses rod-like, broader at base, posterior apophyses long and thin posterior, longer than the anterior apophyses; ostium bursae somewhat broad, centrally placed, funnel-like; ductus bursae moderately long, broader near ductus bursae, coiled near corpus bursae, weakly sclerotized; corpus bursae somewhat large, subovate in shape, weakly sclerotized; signum crescent shaped.

Material examined

Holotype: Himachal Pradesh: Dist. Solan, UHF Nauni, 1360 m, 10.ix.1998, 1♂.

Paratypes: Himachal Pradesh: Dist. Mandi, Tanyhar, 1120 m, 17.vii.1999, 1♀; Dist. Solan, UHF Nauni, 1360 m, 10.ix.1998, 1♂; 12.ix.1999, 3♂♂.

Larval host plant

Unknown.

Remarks

As mentioned elsewhere under the remarks of *Anarsia renukaensis* sp. nov., the species *A. valvata* sp. nov. is quite close to it but differ in the shape and armature of the left valva in the male genitalia.

Etymology

The name of the species i.e., *Anarsia valvata* sp. nov. is derived in view of different structure of the valvae in the male genitalia.

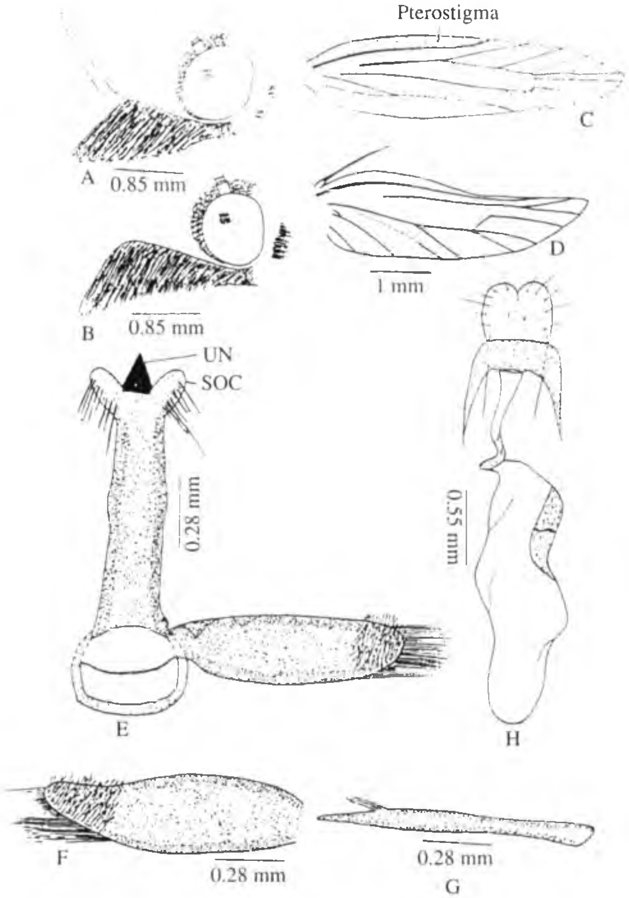
***Anarsia renukaensis* sp. nov.**

Male and female

Alar expanse: 12 mm. Vertex and frons covered with deep grey scales; labial palpus long, upturned, second segment with light grey scales, the latter arranged subtriangularly, male with third segment relatively reduced, female with third segment long, acute greyish black in colour, antenna filiform, about 3/4th length of the forewing, black and grey and alternatively; thorax fuscous; forewing light grey scaled, costa slightly arched at base then straight, apex acute, termen margin convex, tornus margin poorly defined, anal margin convex, costa with one crescent shape black spot at the middle, at side five to six black irregular bloach, one black streak in the discal cell, termen with cilia greyish black, apices white in colour; hindwing somewhat quadrate, costa convex at base then straight, apex subacute, termen margin obtuse, tornus margin ill defined, anal margin slightly convex, termen and anal margin with cilia deep grey in colour; prothoracic and mesothoracic legs fuscous in colour; metathoracic leg grey, hind tibia with small grey hair.

Wing venation (Plate 4, Figs C–D)

Forewing with Sc ending almost at middle of costa, pterostigma between costal margin and Sc ending at R_1, R_1 arising before middle of discal cell, R_2 free, R_3 arising before angle of discal cell, $R_4 + R_5$ long stalked, arising at angle of cell, R_5 to costa, M_1 free, M_1 closer to R_5 than M_2, M_2, M_3 free, CuA_1 and CuA_2 free, CuA_1 closer to CuA_2 at ending, discal cell closed, 1A+2A forked, ending beyond middle; hindwing



Anarsia renukaensis sp. nov.

PLATE 4. *Anarsia renukaensis* sp. nov.: Figures: (A) Labial palpus female; (B) Labial palpus male, (C) Forewing venation; (D) Hindwing venatin; (E) Male genitalia : ventral view; (F) Left valva : ventral view; (G) Aedeagus; (H) Female genitalia : ventral view.

with $Sc+R_1$ arising at base, ending beyond middle of costa, $Rs+M_1$ stalked, Rs to costa, M_1 to termen, M_2 free, nearer to M_1 than M_3, M_3 and CuA_1 connate, CuA_1 and CuA_2 free, CuA_2 ending at middle of anal margin, CuP vestigial, visible at anal margin, 1A+2A forked at base, 3A present.

Male genitalia (Plate 4, Figs E–G)

Uncus triangular in shape, broader at base, apex acute; a pair of socii present, small in size, somewhat rounded, bearing long hair directed proximally, small hair directed distally; tegumen somewhat long, longer than valvae, wall heavily sclerotized, slightly

dialated at middle; vinculum U-shaped, thin; saccus absent; juxta slit-like, weak; valvae asymmetrical, right valva broad and elongate, costal margin almost straight, sacculus margin narrowed at base then slightly convex, cucullus bearing long modified scales on the inner surface, margin drosodistally convex, rounded apex, convex ventro-distally; left valva long, somewhat brinjal-shaped, broader at base, narrowed at apex, costal margin convex, sacculus margin slightly convex, cucullus inner surface bearing short stalked modified scales, long hair on the apical portion on the outer side, margin somewhat convex dorso-distally, apically rounded, slightly convex ventro-distally; aedeagus long, straight, broader at apex and before coecum, coecum small, rounded apex; vesica lacking cornutus.

Female genitalia (Plate 4, Fig. H)

Pallae anales somewhat large, rounded, sparsely setose; anterior apophyses rod-like, broader at base, posterior apophyses long and thin, posterior apophyses longer than anterior apophyses; ostium bursae slightly broader, open at center; ductus bursae small, thin at middle; corpus bursae subovate in shape, slightly sclerotized; a cresent shaped signum present.

Material examined

Holotype: Himachal Pradesh: Dist. Sirmour, Renuka Lake, 740 m, 13.iv.1999 1♂.

Paratypes: Himachal Pradesh: Dist. Sirmour, Renuka Lake, 740 m, 13.iv.1999 1♂; 14.iv.1999, 2♀.

Larval host plant

Unknown.

Remarks

Anarsia renukaensis sp. nov. and *A. valvata* sp. nov. are closely allied to each other in respect of their wing maculation. However, they can easily be separated on the basis of shape of the valvae in the male genitalia. In the former species, the valvae are beset with long hair in their discal protions and the left valva is more or less brinjal-shaped. In the latter species, the valvae are without long hair and the left valva is elongated.

Etymology

Anarsia renukaensis sp. nov. is named after the type-locality i.e. Renuka, which is a holy place, situated about 35 km from Nahan Paunta road (via-Dadhu) in Himachal Pradesh in the Western Himalaya.

***Anarsia didymopa* Meyrick**

Anarsia didymopa Meyrick 1916, *Exot. Microlepid.*, 1, p. 583.

Male genitalia (Plate 2, Figs A–C)

Uncus triangular in shape, broader at base, acute apically; a pair of socii present, rounded, extended distally, studded with long dense hairs; gnathos wanting; tegumen elongate, longer than valvae, moderately sclerotized in the distal half, slightly dilated at middle and base; vinculum U-shaped, weakly sclerotized; saccus absent; juxta slit-like, weakly sclerotized; valvae asymmetrical, right valva leaf-like, costal margin straight, slightly concave at 3/4th, sacculus margin narrowed basally, convex at middle then almost straight, cucullus furnished with modified scales on the inner surface, long stalked, margin dorso-distally convex, apex rounded, ·straight ventro-distally; left valva almost leaf-like, costa convex at 2/5 then almost straight, sacculus almost convex, bearing a small membranous spinous lobe on ventral margin, cucullus with long stalked modified scales on inner surface, margin concave dorso-distally, rounded at apex, almost straight ventro-distally; aedeagus long, slightly bent at middle, apex rounded, coecum small, with its apex somewhat pointed; vesica lacking cornutus.

Female genitalia (Plate 2, Fig. D)

Papillae anales large, somewhat rounded, sparsely setose; anterior apophyses small, rod-like, broader at base, posterior apophyses long and thin, longer than anterior apophyses; ostium bursae somewhat funnel-like, broad, centrally placed; ductus bursae comparatively smaller and broad, narrowed at middle, curved near corpus bursae; corpus bursae large, subovate in shape, moderately sclerotized; a crescent shaped signum present.

Alar expanse

Male and Female: 10 mm.

Material examined

Uttaranchal: Dist. Dehradun, FRI Dehradun, 700 m, 9.viii.1999, 1♂, 1♀; 19.viii.1999, 1♂; 28.ix.1999, 1♂; 6.x.1999, 1♂.

Punjab: Dist. Patiala, PUP, 250 m, 12.viii.1999,2♀.

Distribution

India (Pusa, Bengal) and Thailand, (Park and Ponomarenko, 1996).

Larval host plant

Capparis horrida (Fletcher, 1921).

Remarks

Anarsia didymopa Meyrick is so far known from a single specimen from Pusa, Bengal in India (Meyrick, 1916; Clarke, 1965). The localities such as Dehradun (Uttaranchal) and Patiala (Punjab) from where the collection of seven specimens have presently been made are the additional localities from North-West India for the species, under reference.

***Anarsia parkae* sp. nov.**

Male and female

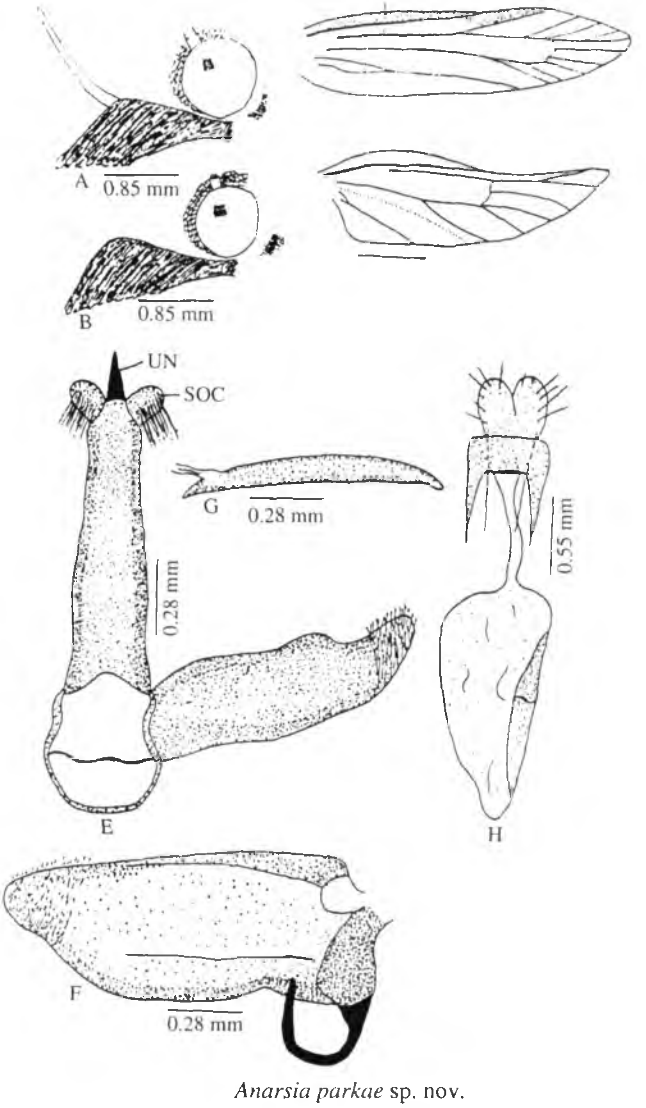
Alar expanse: 12 mm. Vertex and frons decorated with deep grey scales; labial palpus long, upturned, second segment covered with light scales, the latter arranged subtriangularly, third segment relatively reduced in male, female with third segment long, acute, greyish black in colour; antenna filiform, less than 3/4th length of forewing; forewing elongate, light grey scaled, with black shades, costal margin slightly convex at base, concave at middle, apex subacute, termen oblique, tornus margin ill defined, anal margin convex, costal margin with a cresent shape black spot at middle, surrounding on either side small irregular bloaches, termen with cilia light greyish black, apices white in colour; hindwing grey scaled, somewhat quadrate, costal margin arched at base to middle then straight, apex acute, termen oblique, tornus poorly defined, anal margin straight, basally convex, anal and termen margin with cilia deep grey in colour, prothoracic and mesothoracic legs fuscous in colour, metathoracic leg grey, hind tibia beset with blackish grey scales.

Wing venation (Plate 5, Figs C–D)

Forewing with Sc beyond middle of costa, pterostigma between Sc and wing margin ending at R_1, R_1 arising at middle of discal cell, R_1, R_2, R_3 free, R_2 closer to R_3 than R_1, $R_4 + R_5$ stalked, stalk originated from angle of discal cell, R_5 to costa, M_1, M_2, M_3 free, M_1 nearer to R_5 than M_2, CuA_2 free, CuA_2 arising beyond middle of discal cell, 1A+2A forked at base, 3A absent; hindwing with $Sc+R_1$ arising at base, ending almost at middle of discal cell, $Rs+M_1$ long stalked, Rs to costa, M_1 to termen, M_2 free, M_3 and CuA_1 connate, CuA_2 arising beyond middle of discal cell, CuP vestigial, ending near CuA_2, 1A+2A short forked at base.

Male genitalia (Plate 5, Figs E–G)

Uncus triangular in shape, broad at base, apex acute; a pair of socii present, rounded, small, extended distally, bearing small tufts of hair at the middle; gnathos absent; tegumen elongate, longer than valvae, wall well sclerotized, slightly dilated at middle; vinculum U-shaped, thin; saccus absent; juxta slit-like, weak; valvae asymmetrical, right valva elongate, costal margin convex at 3/4th, sacculus margin moderately sclerotized at base, concave basally then convex, cucullus bearing bunch of modified scales on the inner surface, short stalked, straight dorso-distally, rounded apex,



Anarsia parkae sp. nov.

PLATE 5. *Anarsia parkae* sp. nov.: Figures: (A) Labial palpus female; (B) Labial palpus male, (C) Forewing venation; (D) Hindwing venatin; (E) Male genitalia : ventral view; (F) Left valva : ventral view; (G) Aedeagus; (H) Female genitalia : ventral view.

convex ventro-distally; left valva broad and cylindrical, costal margin almost straight, with U-shaped strongly curved process directed towards costa, originate from the base of the valva near ventral margin, sacculus margin convex, cucullus bearing

short stalked modified scales on the inner surface, cucullus slightly convex dorso-distally, rounded apically, concave ventro-distally; aedeagus long, slightly arched, apex rounded, coecum small, pointed apex; vesica without cornutus.

Female genitalia (Plate 5, Fig. H)

Papillae anales large, somewhat rounded, sparsely setose; anterior apophyses rod-like, broader at base, posterior apophyses long and thin, longer than anterior apophyses; ostium bursae, somewhat broad, funnel-like; ductus bursae comparatively smaller, broader near ostium bursae and middle; corpus bursae large, weakly sclerotized, ovate in shape; a crescent shaped signum present.

Material examined

Holotype: Himachal Pradesh: Dist. Mandi, Tanyhar, 1120 m, 16.vii.1999. 1♂.

Paratypes: Himachal Pradesh: Dist. Mandi, Tanyhar, 1120 m, 16.vii.1999, 1♂, 1♀; 17.vii.1999, 1♂.

Larval host plant

Unknown.

Remarks

Anarsia parkae sp. nov. and *A. tanyharensis* sp. nov. are closely allied to each other as far as maculation of their forewings is concerned. However, both can be distinguished from each other in view of differences in structure of the tegumen and left valva in the male genitalia. In the former species, the left valva possesses a strongly curved U-shaped process which originates from the base near ventral margin and is directed towards to costa. In the latter species, the strongly curved process originates from the middle of the basal region of the valva and is directed towards sacculus.

Etymology

Dr. K. T. Park of Korea has continuously been working on the family Gelechiidae for the past many years. In view of her contribution in Gelechiid taxonomy, the species is named as *Anarsia parkae* sp. nov. in her honour.

***Anarsia tanyharensis* sp. nov.**

Male

Alar expanse: 12 mm. Vertex and frons decorated with grey scales; labial palpus long, upturned, second segment covered with light grey scales, the latter arranged subtriangularly, third segment relatively reduced in male; antenna filiform, about 3/4th length of forewing, deep grey in colour; thorax fuscous in colour; forewing elongate, light greyish black scaled, costal margin arched, apex acute, termen margin oblique,

tornus margin ill defined, anal margin convex, costa with one black triangular spot at middle, termen with cillia greyish black, apices white in colour; hindwing grey scaled, somewhat quadrate, costal margin convex at base, apex acute, termen margin oblique, tornus poorly defined, anal margin convex at base, anal and termen margin with cilia deep grey in colour; prothoracic and mesothoracic legs fuscous in colour, metathoracic leg grey in colour, hind tibia with grey hair.

Wing venation (Plate 6, Figs B–C)

Forewing with Sc ending at middle of costa, pterostigma between Sc and costa ending at R_1, R_2 arising at middle of discal cell, R_1, R_2, R_3 free, R_2, nearer to R_3 than R_1, $R_4 + R_5$ long stalked, arising at angle of discal cell, R_5 to costa, M_1 free, closer to R_5 than M_2, M_2, M_3 free, CuA_1 and CuA_2 free, CuA_1 nearer to M_3 than CuA_2, discal cell closed, 1A+2A forked basally, ending nearer to CuA_2, 3A absent; hindwing with $Sc+R_1$ arising at base, ending at middle of costa, $Rs + M_1$ short stalked, R_5 to costa, M_1 to termen, M_2 free, M_3 and CuA_1 connate, CuA_2 arising at middle of discal cell, discal cell closed, CuP free, arising at base, ending near CuA_2, 1A + 2A short forked at base, 3A present.

Male genitalia (Plate 6, Fig. D–F)

Uncus triangular in shape, broad at base, apex acute; a pair of socii almost rounded, extended distally, bearing small hair at middle; gnathos absent; tegumen elongate, longer than valvae, wall well sclerotized, slightly dilated below middle; saccus absent; juxta slit-like, weak; valvae asymmetrical, right valva elongate, costal margin straight from base to 3/5th then slightly convex, sacculus margin straight, convex at base, cucullus bearing modified scales on the inner surface, short stalked, margin convex dorso-distally, rounded at apex, convex ventro-distally; left valva broader at base, narrowed at apex, somewhat cylindrical, costal margin slightly convex upto 2/3rd then gradually narrowed, a strongly curved process originating from the middle of the basal region directed towards sacculus, sacculus margin convex, near middle of the distal half bearing a thumb-like protrubrence, cucullus bearing short stalked bunch of modified scales on the inner surface, margin straight dorso-distally, rounded apically, slightly convex ventro-distally; aedeagus long, slightly curved at 3/5th, apex almost rounded, coecum small, with pointed apex; vesica lacking cornutus.

Female genitalia

Not studied.

Material examined

Holotype: Himachal Pradesh: Dist. Mandi, Tanyhar, 1120 m, 16.vii.1999, 1♂.

Paratypes: Himachal Pradesh: Dist. Mandi, Tanyhar, 1120 m, 16.vii.1999, 2♂♂.

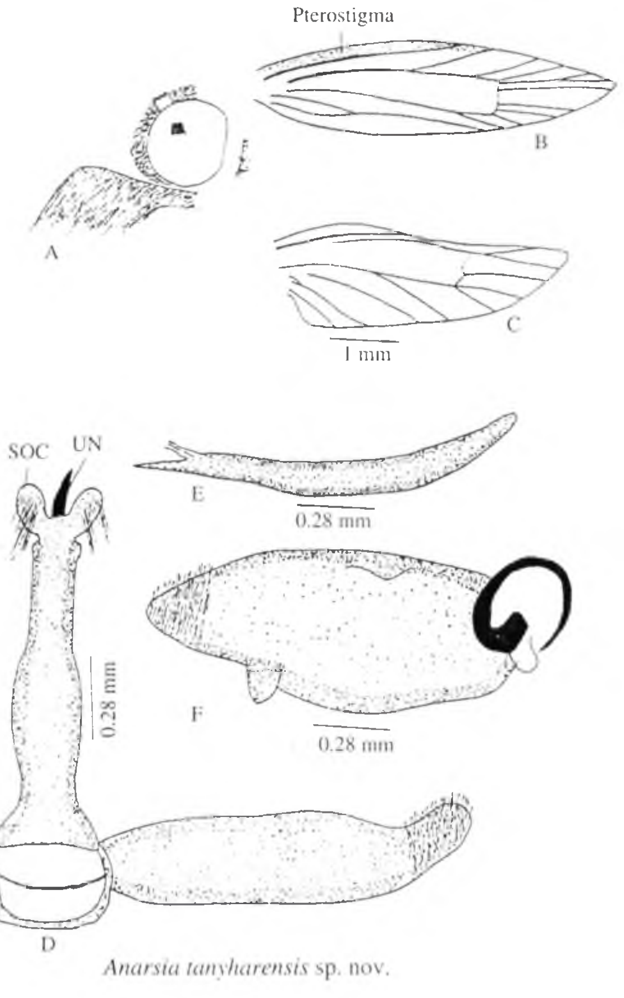


PLATE 6. *Anarsia tanyharensis* sp. nov.: Figures: (A) Labial palpus male; (B) Forewing venation; (C) Hindwing venation; (D) Male genitalia : ventral view; (E) Aedeagus; (F) Left valva : ventral view.

Larval host plant

Unknown.

Remarks

As explained under the remarks of the species *Anarsia parkae* sp. nov., *A. tanyharensis* sp. nov. is closely allied to it and both can be separated as per characters mentioned in the key.

Etymology

The species is named as *Anarsia tanyharensis* sp. nov. after the name of its type-locality i.e., Tanyhar (Mandi) in Himachal Pradesh.

Anarsia triglypta Meyrick

Anarsia triglypta Meyrick, 1933, *Exot. Microlepid*, **4**, p. 354.

Male genitalia (Plate 7, Figs A–C)

Uncus hook-like, small; a pair of socii present, with densly long hair; gnathos absent; tegumen long and broad, longer than valvae, wall heavily sclerotized, dilated at middle; vinculum U-shaped, thin; saccus absent; juxta slit-shaped, weak; valvae asymmetrical, arm-like, right valva with costal margin almost straight, convex at middle, sacculus margin concave at 1/3rd, bearing a small membranous setose lobe, cucullus with short stalked modified scales on the inner surface, margin convex dorso-distally, rounded apically, convex ventro-distally; left valva broader at base narrowed apically, costal margin slightly convex beyond middle, sacculus concave at middle, with large membranous sclerotized lobe near base, cucullus bearing somewhat long stalked modified scales on the inner surface, margin dorso-distally almost straight, apex rounded, convex ventro-distally; aedeagus small, slightly bent at middle, apex pointed, coecum small, apex pointed ; vesica lacking cornutus.

Female genitalia (Plate 7, Fig. D)

Papillae anales small and narrow, almost rounded, sparsely setose; anterior apophyses rod-like, broader at base, posterior apophyses long, thin, posterior apophyses longer than anterior apophyses; ostium bursae opening wide, centrally placed; ductus bursae small, weakly sclerotized near ostium bursae, bent at middle, ductust seminalis arising from the junction of the corpus bursae; corpus bursae subovate in shape; signum crescent shaped.

Alar expanse

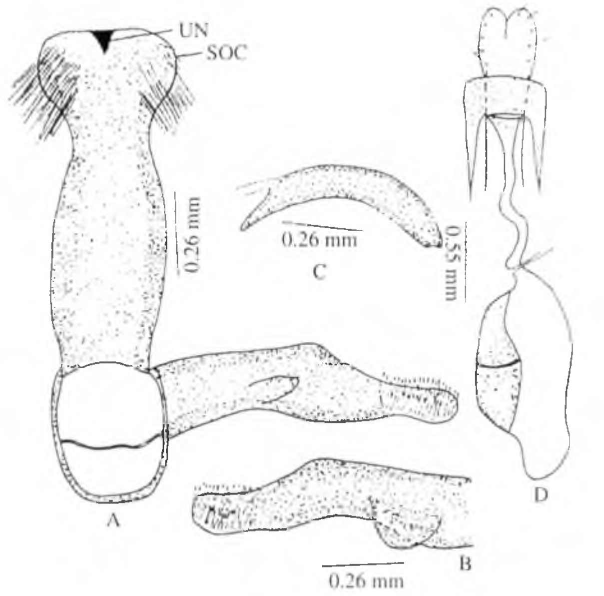
Male and Female: 10–12 mm.

Material examined

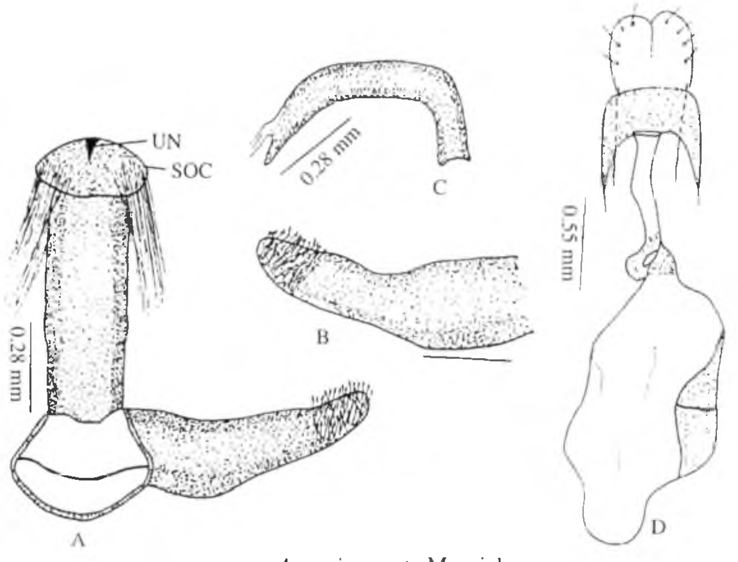
Punjab: Dist. Patiala, PUP, 250m, 24.iii.1998, 1♀; 30.viii.1998, 3♂♂, 1♀; 31.viii.1998, 1♂, 1♀; 3.ix.1998, 1♂, 1♀; 5.ix.1998, 3♂♂; 13.ix.1999, 2♂♂; 14.ix.1999, 3♂♂, 1♀; 15.ix.1999, 1♀; 16.xi., 1999, 1♀; 22.ix.1999, 1♀; 23.ix.1999, 1♀, 1♂, 27.ix.1999, 1♀; 30.ix.1999, 2♂♂; 3.x.1999, 2♀♀; 6.x.1999, 4♂♂; 13.x.1999, 3♂♂.

Distribution

India (Bihar, Pusa) (Clarke, 1969).



Anarsia trigylpta Meyrick



Anarsia veruta Meyrick

PLATE 7. *Anarsia triglypta* Meyrick: Figures: (A) Male genitalia : ventral view; (B) Left valva : ventral view; (C) Aedeagus; (D) Female genitalia : ventral view.

Anarsia veruta Meyrick Meyrick: Figures: (A) Male genitalia : ventral view; (B) Left valva : ventral view; (C) Aedeagus; (D) Female genitalia : ventral view.

Larval host plant

Acacia catechu (Clarke, 1969).

Remarks

During the course of present studies, a phenon comprising thiry-five individuals referable to the species, *Anarsia triglypta* Meyrick has been ensured as conspecific after examination of the male genitalia in nine cases (Clarke, 1969). The species seems to be very common as per material collected from the aforesaid locality (Patiala: Punjab) in North-West India. However, it seems appropriate to record here that Meyrick (1933) has named this species on the basis of a single headless specimen from Bihar, Pusa (India), which was bred from a larva feeding on the leaves of *Acacia catechu* (Clarke, *loc. cit.*).

Anarsia veruta Meyrick

Anarsia veruta Meyrick, 1918, *Exot. Microlepid.*, **2**, p. 148.

Male genitalia (Plate 7, Figs A–C)

Uncus hook-like, small; a pair of socii present, somewhat flatened, extended distally, bearing very long densely hair; tegumen small, shorter than valvae, wall heavily sclerotized, narrowed proximally, broader distally; vinculum U-shaped, weakly sclerotized; saccus absent; juxta slit-like, weak; valvae asymmetrical, right valva elongate, broader at base, narrowed distally, costal margin concave at middle, sacculus margin basal half straight, cucullus margin bearing modified scales on the inner surface, margin convex dorso-distally, apically rounded, convex ventro-distally; left valva elongate, costal margin almost straight from base to middle, concave at middle, sacculus margin basally half convex, cucullus margin bearing short stalked modified scales, margin convex dorso-distally, apex rounded, slightly convex ventro-distally; aedeagus small, C-shaped, apex pointed, slightly bent distally, coecum small, pointed apically; cornutus absent in vesica.

Female genitalia (Plate 7, Fig. D)

Papillae anales large, almost rounded, sparsely setose; anterior apophyses rod-like, broader at base, posterior apophyses long, thin, longer than anterior apophyses; ostium bursae somewhat funnel-like, centrally placed; ductus bursae broader near ostium bursae, narrow medially, coiled near corpus bursae, weakly sclerotized; corpus bursae small, subovate in shape; a crescent shape signum present.

Alar expanse

Male and Female: 11 mm.

Material examined

Himachal Pradesh: Dist. Kangra, KV Palmpur, 700m, 24.vi.1999, 1♀; 26.vi.1999, 1♂; 17.iv.2000, 1♂.

Distribution

India (Bengal, Pusa) (Clarke 1969).

Larval host plant

Inga dulcis (Fletcher, 1921).

Remarks

Clarke (1969) has furnished a photograph of the female genitalia of the species i.e., *Anarsia veruta* Meyrick. This species was named as new on the basis of a lone specimen, which was bred from the pupa on *Inga dulcis* (Leguminosae) (Clarke, *loc.cit.*). During the course of present studies, only two males and one female individuals could be collected from the Western Himalaya. Besides giving an illustrated account of the female genitalia, the male genitalia is examined for this first time.

***Anarsia reciproca* Meyrick**

Anarsia reciproca Meyrick, 1920, *Exot. Microlepid.*, **2**: 300.

Male genitalia (Plate 8, Figs A–C)

Uncus small, hook-like; a pair of socii present, almost rounded, bearing small hair; gnathos absent; tegumen long, longer than valvae, almost straight, wall sclerotized; vinculum U-shaped, broader at middle, thinner at base; juxta slit-like, weak; saccus absent; valvae almost asymmetrical, arm-like, right valva costal margin broader at base, strongly concave at middle, bearing a setose, sclerotized lobe near base, sacculus margin basally concave then convex, cucullus with short stalked modified scales on the inner surface, dorso-distally somewhat convex, apically rounded, convex ventro-distally; left valva costal margin slightly concave at middle, bearing a small setose lobe near base, sacculus margin almost straight, convex at base, cucullus bearing short stalked modified scales on the inner surface, margin slightly convex dorsally, apically somewhat rounded, convex ventrally; aedeagus small, bent at middle, apically broad, apex pointed, concave at apex, coecum pointed at apex; vesica lacking cornutus.

Female genitalia (Plate 8, Fig. D)

Papillae anales small, somewhat rounded, weakly setose; anterior apophyses rod-like, broad at base, posterior apophyses long, thin, posterior aphyses longer than anterior apophyses; ostium bursae funnel-like, weakly sclerotized near ostium bursae; ductus

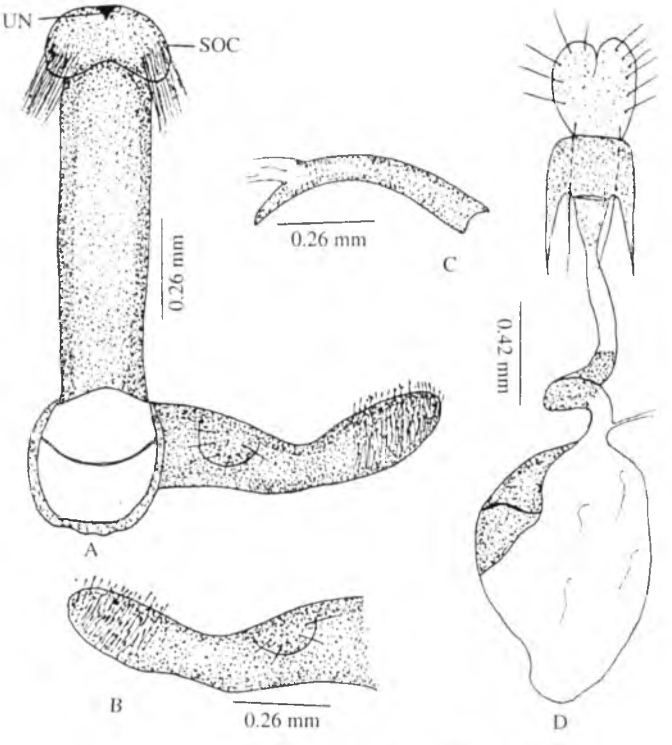


PLATE 8. *Anarsia reciproca Meyrick*: Figures: (A) Male genitalia : ventral view; (B) Left valva : ventral view; (C) Aedeagus; (D) Female genitalia : ventral view.

bursae slightly large, coiled beyond middle, weakly sclerotized, ductus seminalis arising near base of the ductus bursae; corpus bursae subovate in shape; a crescent shape signum present.

Alar expanse
Male and Female: 11–12 mm.

Material examined

Uttaranchal: Dist. Dehradun, FRI Dehradun, 700 m, 2.vi.1998, 4♂♂, 5♀♀; 3.vi.1998, 5♂♂, 4♀♀.

Himachal Pradesh: Dist. Mandi, Tanyhar, 1120m, 27.vi.1998, 5♀♀.

Distribution

India (Madras), Coimbatore (Clarke, 1969).

Larval host plant

Unknown.

Remarks

Having already known from Madras (India) (Clarke, 1969), *Anarsia reciproca* Meyrick is being reported for the first time from Doon Valley (Uttaranchal) and Tanyhar (H.P.) in the Western Himalaya. Three males and four females of this species from the aforesaid localities were dissected in order to confirm their conspecificity.

DISCUSSION

During the course of present studies, it has been noted that the third segment of the labial palpi is vestigial in the males and in the male genitalia the gnathos is completely lacking and inner surface of the valvae possesses modified scales in all the ten species referable to the genus *Anarsia Zeller*. According to Ueda (1997), these characters show a monophyly in this genus. However, on the basis of forewing pattern and structure of the male and female genitalia, Ponomarenko (1989) recognized two subgenera i.e., *Anarsia (s.s.)* and *Ananarsia (s.l.)*. Workers like Real (1994) and Park (1995) rather than following this proposal of employing the subgeneric category have laid more stress on recognition of certain species groups such as *spartiella and lineatella* species-group (Park, 1995) and A, B, C, D groups (Ueda, 1997).

In the present studies, the genus *Ananarsia* has been taken as a synonym of *Anarsia* following Ueda (1997). Out of one hundred species worldwide (Meyrick, 1925; Gaede, 1937; Janse, 1949, 1963; Clarke, 1965, 1969; Ponomarenko, 1989; Park, 1991, 1995; Ueda, 1997; Park and Ponomarenko, 1996b,c), twenty-one species have been listed from different region of India other than North-Western Siwaliks (Gaede, *loc. cit.*; Clarke, 1969). Accordingly, the material presently dealtwith and referable to ten species i.e., *Anarsia tegumentus* sp. nov., *A. patulella* (Walker), *A. valvata* sp. nov., *A. renukaensis* sp. nov., *A. didymopa* Meyrick, *A. parkae* sp. nov., *A. tanyharensis* sp. nov., *A. triglypta* Meyrick, *A. veruta* Meyrick and *A. reciproca* Meyrick from Siwaliks in North-West India becomes the first report. The critical examination of the male genitalia of these species shows that the uncus is always present, the socii well developed and the gnathos is always wanting. The tegumen is generally elongated and slender. The valvae are asymmetrical and furnished with modified scales at their distal ends.

These characters reveal that all the ten species form a natural group of congeneric species. Besides, the monophyly due to vestigial third labial palpi, absence of gnathos and presence of modified scales on the inner surface of valvae also conform to the observations made by Ueda (1997). Further, the congeneric nature of the species is duly supported by the female genitalia in having cresent shaped signum in the corpus bursae and the posterior apophyses being longer than the anterior apophyses in eight species i.e., *Anarsia didymopa* Meyrick, *A. patulella* (Walker), *A. triglypta* Meyrick,

A. veruta Meyrick, *A. reciproca* Meyrick, *A. parkae* sp. nov., *A. renukaensis* sp. nov. and *A. valvata* sp. nov.

Key to the species of the genus *Anarsia*

1.	Forewing with a small black bloach at middle of costa; hindwing with veins M_3 and CuA_1 connate prior to posterior angle of discal cell; male genitalia with uncus straight, slit-like, tegumen chimni-shaped, left valva with cucullus hook-like moderately long process ventro-distally	*tegumentus sp. nov.*
–	Forewing with cresent-shaped spots on costa or black streak on upper surface of wing; hindwing with veins M_3 and CuA_1 connate from posterior angle of discal cell; male genitalia with uncus triangular or hook-like, tegumen not as above, left valva without hook-like process	**2**
2.	Forewing with cresent-shaped spots on costa; male genitalia with uncus triangular in shape	**3**
–	Forewing with black streaks on upper surface; male genitalia with uncus hook-like	**8**
3.	Male genitalia with each valva subtrapazoidal, cucullus margin spiny apically, left valva with sacculus bearing a spine	*patulella* Walker
–	Male genitalia with valva not as above, cucullus margin spineless, left valva with sacculus without spine	**4**
4.	Male genitalia with right valva bearing a large rectangular flap-like structure joining the sacculus margin and cucullus	*valvata* sp. nov.
–	Male genitalia with right valva not as above	**5**
5.	Male genitalia with tegument heavily sclerotized, valva with long hair in distal portion on outer surface, left valva brinjal-shaped	*renukaensis* sp. nov.
–	Male genitalia with tegumen moderately sclerotized, valva without long hair in distal portion on outer surface, left valva not as above	**6**
6.	Male genitalia with valva leaf-like, cucullus with very long stalked modified scales on inner surface, left valva with sacculus with a small membranous lobe on ventral margin, aedeagus elongated, coecum long	*didymopa* Meyrick
–	Male genitalia with valva not as above, cucullus with short stalked modified scales on inner surface, left valva with sacculus devoid of lobe, aedeagus relatively smaller, coecum short	**7**

7. Male genitalia with left valva having a U-shaped strongly curved process, the latter directed towards costa, originating from base of valva near ventral margin, sacculus without thumb-like protrusion on distal half .... *parkae* sp. nov.

– Male genitalia with left valva with a strong curved process originating from middle of the basal region directed towards sacculus, sacculus with thumb-like protrusion on distal half .... *tanyharensis* sp. nov.

8. Male genitalia with valva arm-like, tegumen dilated from base to distal end, left valva having a relatively large membranous lobe at base, aedeagus arched .... *triglypta* Meyrick

– Male genitalia with tegumen simple, long or small, valva long, basally broad, left valva without membranous lobe, aedeagus not as above **9**

9. Male genitalia with socii beset with very long hair, directed posteriorly, tegumen small in size, broader in distal half, valva with costa almost straight basally, less concave at middle, without lobe, aedeagus C-shaped ... *veruta* Meyrick

– Male genitalia with socii beset with small hair, directed slightly posteriorly, tegumen uniformly broader throughout, valva with costa convex basally, strongly concave at middle, bearing a small, sclerotized, sparsely setosed lobe at base of costa, aedeagus gradually curved .... *reciproca* Meyrick

Abbreviations

1A + 2A	Vein representing fused first and second anal vein	R_3	Third radial vein
3A	Third anal vein	R_4	Fourth radial vein
CuA_1	First anterior cubital vein	R_5	Fifth radial vein
CuA_2	Second anterior cubital vein	Rs	Radial sector
CuP	Posterior cubital vein	Sc	Subcostal vein
FRI	Forest Research Institute	$Sc+R_1$	Stalk of subcostal and first radial vein
KV	Krishi Vishvavidyalya	S.I.	Sensu lato
M_1	First median vein	SOC	Socii
M_2	Second median vein	sp. nov.	New species
M_3	Third median vein	s.s.	Sensu stricto
PUP	Punjabi University, Patiala	UHF	University of Horticulture and Forestry
$\mathbf{R_1}$	First radial vein	UN	Uncus
$\mathbf{R_2}$	Second radial vein		

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Immunoelectronmicroscopic localization of lipophorin in different tissue organelles of the red cotton bug, *Dysdercus cingulatus*

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ABSTRACT: Using affinity purified polyclonal antilipophorin antibody, sites of lipophorin synthesis were identified in the visceral fat body, ovary and midgut of adult *Dysdercus cingulatus*. Lipophorin was detected in the endoplasmic recticulum, Golgi apparatus and small vesicles located in the trans Golgi network region as well. These locations are interpreted as the secretory pathway of nascent lipophorin. Lipophorin associated with the external surface of the superficial and lateral plasma membranes are known to be directly exposed to the haemolymph. This localization pattern suggests the secretion—storage—mobilization pathway and utilization site of lipophorin in *D. cingulatus*.

KEYWORDS: fat body, lipophorin, golgi apparatus, endoplasmic recticulum, gold labeling, *Dysdercus cingulatus*

In insects, the transport of lipids is mediated by lipophorin, a major haemolymph lipoprotein. It is well documented that lipophorin functions as a carrier protein for a number of lipid classes such as diacylglycerol (Chino *et al.*, 1969; Van der Horst *et al.*, 1981), cholesterol (Chino and Gilbert, 1971) hydrocarbons (Katagiri and de Korst, 1991) and phospholipids (Gondim *et al.*, 1989; Atella *et al.*, 1992) from the sites of synthesis to the utilization or storage site. It is known to play a secondary role in transporting riboflavin (Miller and Silhacek, 1993) and xenobiotics (Sharprio, 1989) as well. Lipophorin is also involved in vitellogenesis and lipid metablism (Rayan and Van der Horst, 2000). Recently, it was reported that lipophorin acts as an endogenous signal for immune activation in the larva of the greater wax moth, *Galleria mellonella* (Halwani *et al.*, 2001).

The fat body of insects is the central organ of lipid storage, which takes up diacylglycerol from circulating lipophorin and deposits it after further esterification to triacylglycerol in the form of fat droplets (Beenakkers *et al.*, 1985; Chino, 1985; Keeley, 1985). In addition to lipophorin unloading and loading, fat body cells

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also synthesize and secrete lipophorin into the haemolymph (Gellissen and Wyatt, 1981; Bermàn and Chippendale, 1989; Shelby and Chippendale, 1990). Presence of lipophorin has been demonstrated in the ovary (Yun and Kim, 1996; Machado *et al.*, 1996; Kim *et al.*, 1998) and also in the midgut epithelium of dragonfly larvae (Bauerfeind and Komnick, 1992a).

In the present study, an attempt has been made to localize the possible lipophorin binding regions in the different cellular organelles of visceral fat body, ovary and midgut of *D. cingulatus* by immunocytochemical techniques at electron microscopic level.

The red cotton bug, *Dysdercus cingulatus* was reared in the laboratory on soaked cotton seeds under controlled conditions (27 ± 2 °C; r.h. 90 ± 3 and 12 : 12 L/D cycle). Eggs when hatched were transferred to plastic rearing basins. Newly emerged adults were isolated and were designated as 0-day old.

Fat body, ovary and midgut dissected from two-day-old adult female *D. cingulatus* were fixed in a mixture of 1% glutaraldehyde and 4% paraformaldehyde, buffered in PBS (pH 7.2). After fixation, tissues were washed in cold PBS and made 4 changes at 20 minutes intervals. Post-fixation was done in 1% osmium tetroxide (O_SO_4) prepared in the same PBS for 1 hr at 4°C. Thereafter tissues were washed in PBS (4 times for 10 min in each), prior to dehydration. Dehydration was done in graded series of acetone and toluene. Specimen were infiltrated and embedded in araldite 502 resin. Ultra-thin sections of 60–70 nm were cut using diamond knife on an ultramicrotome (Leica Ultracut UCT, Germany) and mounted on 300 mesh nickel grids for further staining procedure. Nickel grids with sections were placed on 20 μl PBS^+ droplets on parafilm within a petridish for incubation. Freshly prepared non-immune serum from goat was applied on to tissues as blocking agent. After blocking, the grids were transferred directly to specific lipophorin primary antibody. Secondary antibody diluted in PBS^+ was then applied on tissues. Gold (10 nm) conjugated Rabbit anti-Goat IgG (whole molecule) served as the secondary antiserum. Grids were stained in 0.5% aqueous Uranyl acetate and Lead citrate and viewed in Transmission Electron Microscope (Hitachi H 600, Japan) at an accelerating voltage of 75 KV. Gold labelled tissues scanned and electron micrographs were taken. Non-treatment of primary antibodies to sections served as controls.

Immunogold labeling revealed the presence of lipophorin in the Golgi apparatus (Fig. 1a) and endoplasmic recticulum (Fig. 1c). Gold particles were difficult to identify at lower magnifications in the TEM. However, higher magnifications revealed that Golgi apparatus and small vesicles associated with Golgi apparatus and endoplasmic recticulum were labeled with the gold particles. In addition, immunogold label was always observed in membrane bound compartments of various shapes and sizes, some of which are identified as multivesicular bodies. No labeling was found in the control (Fig. 1b and d).

In the ovary, immunolabelling is mostly localized at the oocyte surface (Fig. 1e) specifically at the microvilli of oocytes (Fig. 1f) while no labeling was found in the control (Fig. 1g).

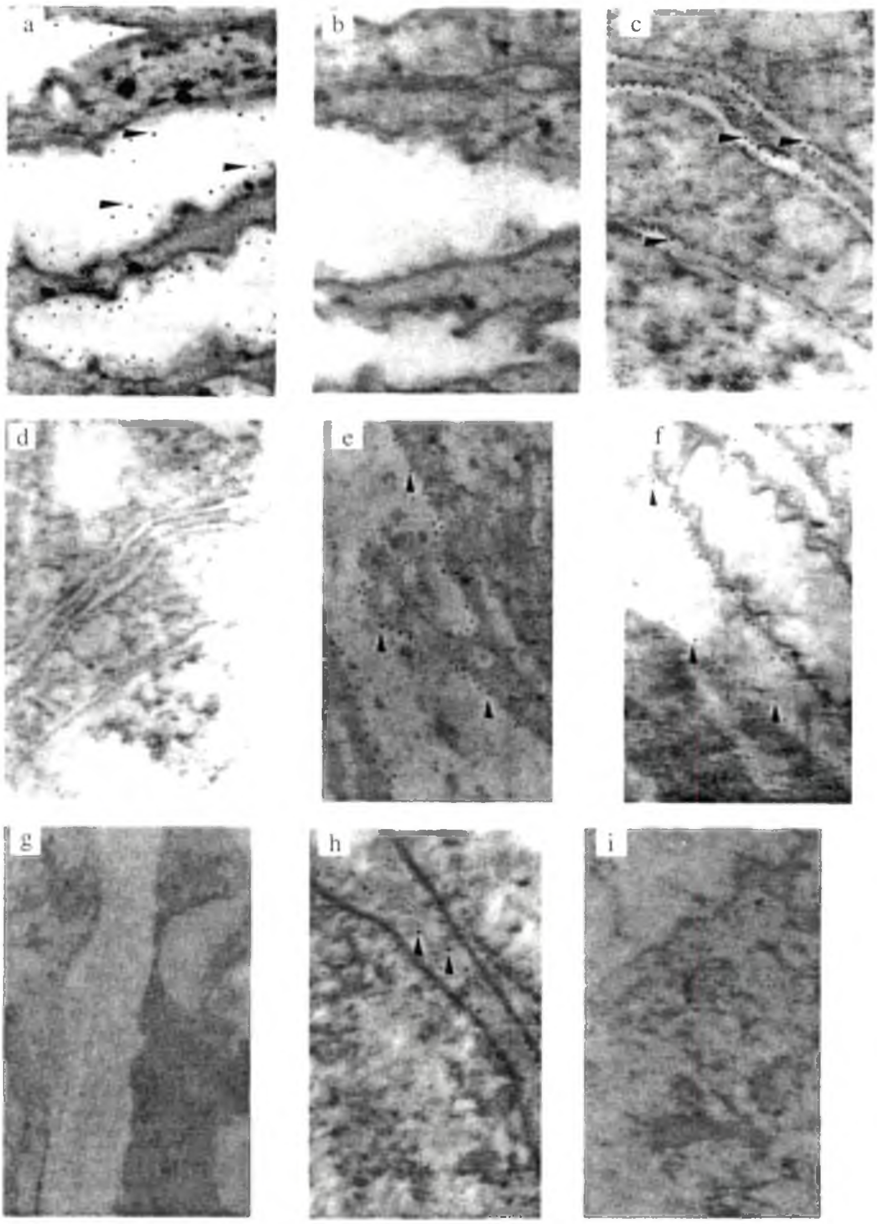

FIGURE 1. Electronmicrographs showing immunolocalization of lipophorin in different tissues. Arrow heads denotes lipophorin localization Fat body: (a) Golgi appraturs (b) Golgi apparatus—Negative control (c) Endoplasmic reticulum (d) Endoplasmic reticulum—Negative control. Ovary: (e) Oocyte (f) Ovarian follicle (g) Negative control. Midgut: (h) Midgut epitheliam (i) Negative control. Gold (10 nm) conjugated Rabbit Anti-Goat 1 gG × 40 000.

In the midgut lipophorin—positive immunogold labeling could be noticed along the intercellular spaces of the midgut epithelium (Fig. 1h) while no labeling was noticed in control preparations (Fig. 1i).

Present localization of lipophorin in the fat body of *D. cingulatus* revealed its presence in the endoplasmic recticulum, Golgi apparatus and also as a number of small Golgi-associated vesicles. In addition to these organelles, immunogold labelling was observed in membrane bound compartments of various shapes and sizes, some of which were, identified as multivesicular bodies. Immunocytochemical localization of lipophorin along the external face of the superficial plasma membranes on the adipocytes corresponds to the extracellular lipophorin localization in the flight muscles of the migrating locust (Van Antwerpen *et al.*, 1988) and to the results obtained on the midgut epithelium of dragonfly larvae, where lipophorin was located outside the cells along the basolateral plasma membranes (Bauerfeind and Komnick, 1992a). These congruous localizations suggest that lipid loading and unloading of lipophorin occurs extracellularly in these insects. Lipophorin receptors could play a role in lipophorin binding to the plasma membrane for lipid unloading (Tsuchida and Wells, 1988, 1990).

These observations also were fully in agreement with the results obtaind by Bauerfeind and Komnick (1992a; 1992b) suggesting that lipophorin is produced in the endoplasmic recticulum and stored in Golgi apparatus as large vesicles. Thus the secretary pathway of lipophorin and possible secretion sites of loading and unloading of lipophorin in fat body as suggested by Bauerfeind and Komnick (1992a; 1992b) are fully supported by the present observation in *D. cingulatus*.

Present studies showed immunolabelling of lipophorin droplets along the intercellular spaces of the midgut epithelium, while no labeling was found inside the midgut. The main organ of lipid loading of lipophorin shuttle is the midgut during absorption of dietary lipids (Turunen, 1979). Gondim and Wells (2000) reported presence of lipophorin binding sites in the midgut of larval *Manduca sexta*. Studies on lipid absorption and transport in several species of insects have shown that lipids are freshly absorbed from the midgut as lipoprotein-bound diacylglycerol and transported to the fat body through the haemolymph (Weintraub and Tietz, 1973; Chino and Kitazawa, 1981; Chino *et al.*, 1981; Thomas, 1984; Beenakkers *et al.*, 1986; Prasad *et al.*, 1986; Shapiro *et al.*, 1988; Van der Horst, 1990; Ryan, 1990). Bauerfeind and Komnick (1992a) stated that lipid loading and unloading of lipophorin are extracellular processes occurring directly at the external face of the basolateral plasma membrane.

Present observation of localizing lipophorin droplets in the ovary mostly at the oocyte surface, especially at the microvilli region, also supports the earlier observations by Machado *et al.* (1996). But no labeling was found inside the oocyte of *D. cingulatus*. Yun and Kim (1996) reported presence of apoLp-III in the haemolymph, ovaries and testes of the *Hyphantria cunea*. But there were reports about the presence of lipophorin inside the oocyte of *Manduca sexta* (Van Antwerpen *et al.*, 1993; Fan *et al.*, 2002).

To conclude, immunoelectronmicroscopic localization reveals the presence of lipophorin troplets in the endoplasmic reticulum, Golgi apparatus and Golgi-

associated vesicles in fat body, intercellular space in midgut epithelium and in the microvilli of ovary. All these findings strongly suggest the secretion—storage—mobilization pathway and utilization site of lipophorin in *D. cingulatus*.

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Effect of ground vegetation and nut characteristics on the severity of infestation by *Aceria guerreronis* in coconut

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ABSTRACT: Injury due to the coconut mite, *Aceria guerreronis* Keifer (Acari: Eriophyidae) in a coconut plantation rich in vegetative cover was less than that in a plantation without such vegetation. Orange coloured fruits (dwarf) were less susceptible to mite infestation than dark green, light green and yellow nuts. Non-angular (spherical) fruits were less susceptible than angular fruits. The mite injury was lower when the perianth radius was less than 2 cm and the perianth cleft angle (the angle between any two of the inner three overlapping bracts at the clefts) was greater than 136°. © 2003 Association for Advancement of Entomology

KEYWORDS: Coconut plantation, ground vegetation, nut characteristics, *Aceria gurreronis*

An exotic pest recently introduced into India (Sathiamma *et al.*, 1998), *Aceria guerreronis* Keifer (Acari: Eriophyidae) infests the perinath-covered meristematic region of the tender nuts (Moore and Alexander, 1987), especially on bunch 3–5 after fertilization (Varadarajan and David, 2002). The infestation results in significant reduction in the yield and economic return (Varadarajan, 2000). The extent of injury to the nuts varies from garden to garden in the same locality. We surveyed the mite infestation in two different gardens, one rich in vegetation on the ground and the other not. We also examined some morphological characteristics of coconut fruits in relation to the mite population density and injury and the results are presented in this paper.

Two separate gardens were selected at Vadakarai in Tamil Nadu. One of them had a wide variety of plant species as ground cover, understorey vegetation and avenues such as: neem (*Azadirachta indica* L., Meliaceae arecanut (*Areca catechu* L., Arecaceae), silk cotton (*Ceiba pentandra*., Bombacaceae), babool tree (*Prosopis spp*., Mimosaceae), golden shower (*Cassia fistula* L., Caesalpiniaceae), drumstick (*Moringa oleifera* Lam., Moringaceae), guava (*Psidium guajava* L., Myrtaceae), subabul (*Leucaena leucocephala* (Lamk), Mimosaceae), nettilingum (*Polyalthia*

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longifolia, Annonaceae), banana (*Musa* spp., Musaceae), papaya (*Carica papaya* L., Caricaceae), curry leaf (*Murraya koenigii* L., Rutaceae), coccinia/little gourd (*Coccinia grandis Voigt.*, Cucurbitaceae), shoe flower (*Hibiscus rosa sinensis*, Malvaceae), hariyali grass (*Cyanodon dactylon.*, Gramineae), calotropis (*Calotropis gigantea* (L.), Asclepiadaceae), cassava/tapioca (*Manihot esculenta Crantz.*, Euphorbiaceae), kalvazhai/Indian shot (*Canna indica L.*, Cannaceae), arali (*Nerium odorum*, Apocynaceae), kuppaimeni (*Acalypha indica*, Euphorbiaceae), and crotons (*Croton* sp., Euphorbiaceae). The other garden lacked such vegetation. In each garden 30 trees were selected at random at the time of harvest and the harvested nuts were grouped into five categories based on the extent of mite infestation, which manifests in scarified injuries on the surface of mature fruits. A new 5-grade score was evolved to assort the harvested nuts into five different groups based on the extent of scarification and fissures on the nut surface as follows: grade 0, nut surface plain and fresh without any injury; grade 1, scarification on the nut surface in random and/or triangular patches; grade 3, contiguous or discontiguous scarification on one-fourths the nut surface down the perianth; grade 5, contiguous or discontiguous scarification on half the nut surface down the pernianth; grade 7, contiguous or discontiguous scarification, either on three-fourths the nut surface with or without fissures and/or gummosis or on less than three-fourths the surface with fissures and/or gummosis, with or without deformation. Since most nuts exhibited injury between grade 3 and 7, they were collectively taken into consideration for statistical analysis and the data on the percentage of severely damaged nuts per palm were compared by a paired t-test.

The palms at one of the State Government Coconut Nurseries at Vadakarai were used to study the diversity in nuts and A. *guerreronis* infestation. They were grouped into four categories based on the nut colour, two categories based on the structural angularity, four categories based on the perianth radius, and five categories based on the perianth cleft angle. The observations on the injury grade were made at the time of harvest from each of the selected trees in respect of each nut character and the percentage of nuts showing severe injury was calculated. The results were compared either by a one-way ANOVA before mean separation by DMRT, or by a t-test. The perianth cleft angle, i.e. angle between any two of the inner three overlapping bracts at the clefts, was measured using a miniature transparent protractor. The sample nuts were collected at random from bunch 3 (post-fertilization) and the population density of *A. guerrernois* in a unit area was assessed using the glycerine-drop-trap method (David and Varadarajan, 2001). An many as 36 drops were placed on each sample nut, including both surfaces of the six bracts as well as the meristematic zone of the nut to arrive at the mean population density per 7 mm^2 per sample nut. One-way ANOVA was performed and the means were separated by DMRT.

It is a common sight that coconut gardens are either neat and tidy without any vegetation, or weedy with ground cover flora, understorey vegetation and other trees. The results revealed that the two plantations differed significantly ($P < 0.01$) in terms of the extent of damage to nuts caused by *A. gunerrernois* (Table 1). The factors that can influence the mite population in such situations need to be studied further.

Vegetative cover in a plantation can directly or indirectly influence the soil fertility and nutrients availabilty, the micro-climate, and the occurrence of natural enemies.

Palms with dark green nuts exhibited significantly ($P < 0.05$) greater damage (62.5%) (Table 1). This is in sharp contrast to the earlier report by Moore and Alexander (1990) who reported that palms with dark green inflorescence suffered less damage. This indicates that the nut colour may not be a reliable character. Light green to mixed colour fruits were found to be moderately susceptible (41.5–48.2%), while dwarf orange nuts appeared least susceptible (6.13%). Other nuts with pale yellow to mixed colour were significantly inferior to dwarf orange nuts but superior to light green ones with only 41.5 per cent of the nuts per palm bearing severe injury. The tolerance in dwarf orange types may be more due to the structure of nuts of their biochemical factors than due to their colour. Dispersal of *A. guerreronis* is wind-aided (Julia and Mariau, 1979) and it is likely to happen especially at night when the inter-inflorescence crossings occur (Moore and Alexander, 1987). Thus, although air-borne, the active mites may have no chance of orienting themselves with colour attraction from the nuts. Architecture of the orange fruits that are more spherical than angular is likely to be the probable reason as discussed below. Biochemical analyses in different cultivars may also help identify the deciding factor.

The coconut fruit is roughly triangular in transverse section, with three sides and angles (Thampan, 1984). However, expression of the angles varies among the cultivars. Thus more angular fruits look elongate and less angular fruits appear spherical in shape. Angular (elongate) fruits were found significantly ($P < 0.01$) more susceptible to *A. guerreronis* than non-angular (spherical) ones (Table 1). Nearly half of the harvested angular fruits were severely damaged by the mite while only one-fourth of the harvested spherical nuts bore significant level of injury. These observations are in agreement with the previous results (Moore and Alexander, 1990).

The radius of perianth whorl differs significantly among the palms. Usually, it ranges from 2 to 3 cm and above. Evidently, the extent of damage increases with increase in perianth radius since more mites can infest the bracts when the latter are larger in size, resulting in significantly ($P < 0.05$) more damage (Table 1). Thus fewer nuts were severely damaged when the perianth radius was less than 2.0 cm. The spherical dwarf orange fruits were of this category. Most nuts were severely damaged when the radius was 3 cm and above. The angular dark green fruits were of this category. Mites caused damage to only 17.06–35.02% fruits when the radius ranged from 2.1 to 2.9 cm.

In coconut fruits the overlapping perianth whorl appears to be clefted at three places on the fruit surface. It is probable that the active mites invade the perianth through the gap likely to occur because of the overlapping of the bracts. The survey indicates that the angle of deviation between any two of the inner three overlapping bracts at the cleft decreased significantly ($P < 0.05$) as the population density of *A. guerreronis* on bunch 3 nuts increased (Table 1). The active mites were significantly more numerous when this angle was less than 135° and significantly fewer when the angle was greater than 135°. This angle was narrow in the elongate angular fruits, wider in the spherical

TABLE 1. Percentage of nuts showing severe mite injury in coconut gardens with undercrop and showing morphological variations

Name of tree/nut	Injured nuts (%)
Type of gardens	
Trees in garden with diverse crops underneath	28.94 (35.81)*
Trees in garden without ground flora	45.81 (43.50)*
Categoryof nuts	
Dark green	62.56 $(52.89)^{a}$
Light green	42.80 $(39.36)^{b}$
Yellow to mixed	41.51 $(43.92)^{bc}$
Orange	6.13 $(10.65)^{c}$
Shape of nuts	
Angular (elongate)	49.39 (44.69)**
Non-angular (spherical)	26.72 (29.09)**
Perianth radius	
<2.0 cm	4.42 $(8.22)^{d}$
2.1–2.5 cm	17.06 $(19.19)^{c}$
2.6–2.9 cm	35.02 $(36.37)^{b}$
> 3.0 cm	60.34 $(51.88)^{a}$
Perianth cleft angle	No. of mites per 7 mm^2
<115°	5.76 $(2.50)^{a}$
115–125°	5.25 $(2.39)^{a}$
126–135	5.23 $(2.30)^{a}$
136–145°	1.10 $(1.26)^{b}$
> 146°	0.97 $(1.21)^{b}$

Figures in parenthesis are angular of $\sqrt{x+0.5}$ transformed values. In a column, means followed by the same letter are not significantly different at 5% level by Duncan's multiple range test. *Significant difference ($P < 0.05$)), $t = 2$. **Significant difference ($P < 0.01$), $t = 7$.

dwarf orange fruits and can be considered a measure of refuge the perianth provides on the nut surface. That is, as the angle gets wider, the refuge is likely to get lesser which is characteristic of the non-angular spherical fruits with smaller bracts providing less mite space. On the other hand, as the angle gets narrower, the refuge is likely to get greater which is typical of the elongate angular fruits possessing larger bracts that provide more space for the mites to colonize. Whereas the bracts can act as a physical barrier to mite entry (Julia and Mariau, 1979) because of the tightness (Howard and Abreu-Rodriguez, 1991), the perianth cleft angle may reflect the physical space which is vital for mite infestation and subsequent population development.

The coconut mite, *A. guereronis* has become so serious a problem in India that it needs both short-term and long-term management strategies that are practicable and eco-friendly. The results of this investigation highlights how the ground vegetation in plantations and the morphological diversity of nuts and perianths can influence the mite infestation and the injury that follows, indicating that the ground vegetation in coconut plantations needs to be encouraged. Coconut trees are highly heterogeneous. Those palms which bear spherical (non-angular) fruits characterized by smaller perianth radius (<2 cm) and wider perianth cleft angle ($>136°$) can tolerate the mite attack. These parameters may be useful while selecting the mother palms intended for seed nuts. However, stabilization of such characters in the tree populations will be difficult to achieve.

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A simple method for collection of insect honeydew

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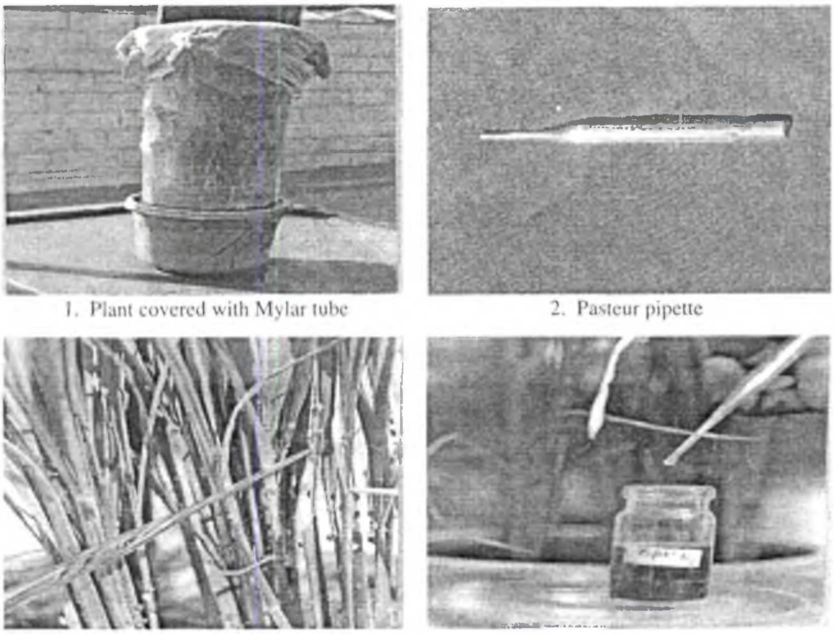
ABSTRACT: A simple method for collection of rice planthopper and leafhopper honeydew by capillary method is described.

KEYWORDS: Insect honeydew, collection, capillary method

Homopteran insects such as aphids, mealy bugs, scales, planthoppers, leafhoppers and whiteflies excrete large amounts of liquid called honeydew which is rich in sugars, some amino acids and waxes. Honeydew acts as a host searching kairomone for various insect parasitoids (Bouchard and Cloutier, 1984) and predators (Heidari and Copland, 1993). Honeydew and its products have also been reported as food sources for many adult insect parasitoids (Bergstrom, 1998) and larval and adult stages of predators (Heidari and Copland, 1993). McEwen *et al.* (1993) observed that they also increase the longevity and fecundity of the insects while sugars and amino acids present in the honeydew act as arrestants and attractants to many parasitoids and predators (Hagen *et al.*, 1976).

For various qualitative and quantitative studies, collection of honeydew in sufficient quantities is required. Several workers have reported different methods of honeydew collection (Pathak *et al.*, 1982; Begum and Wilkins, 1998; Bouchard and Cloutier, 1984; McEwen *et al.*, 1993; Lee Hong and Xu Rumani, 1993). Most of these methods are cumbersome and expensive. Also, small amount of honeydew collected was dried before storage, which may result in the loss of volatile compounds. Moreover, there may be contamination due to death of insects and body fluids. In the present paper a simple method is described for collection of rice leafhopper and planthopper honeydew by capillary collection and its subsequent storage.

Rice plants were heavily infested with nearly 200 nymphs or adults of planthoppers or green leafhoppers and they were caged with mylar tubes. Holes were made in mylar cages and were pasted with muslin cloth for better aeration and to prevent plant decay. Large amount of honeydew was execrted on the plants due to heavy insect infesttion. A Pasteur pipette was used to collect honeydew from plants. The tip of the pipette was placed on honeydew droplet, which was sucked by capillary action (Fig 1). Honeydew in the pipette was then poured into culture tubes and stored in the



1. Plant covered with Mylar tube
2. Pasteur pipette
3. Honeydew collection with pasteur pipette
4. Culture tube with Honeydew

FIGURE 1.

deep freezer at −30°C without dilution or concentration and used for further studies. Whenever necessary, honeydew was concentrated by lyophilization at −80 °C without loss of any chemical substance and diluted and used for bioassay and chemical analysis studies. Following this procedure large amount of honeydew could be collected within a short period. Two ml of honeydew could be collected daily from 200 insects within 30 minutes and the same plant could be used for 3 days.

Compared to earlier techniques, this method is simple, effective and cheap. As the plants are covered with mylar tubes, there is no loss of honeydew due to evaporation from the plant surface. Pasteur pipettes are easily available and cheaper than parafilm used by earlier workers. There is less scope for any contamination of honeydew. As the honeydew is immediately stored in the deep freezer, there will be no loss of chemical constituents or volatiles as in other methods. Fresh honeydew immediately after collection can be used for bioassay studies. This method can be employed for collection of honeydew from other homopteran insects as well.

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Massilieurodes homonoiae (Jesudasan and David) Comb. Nov. (Aleyrodidae: Homoptera)

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ABSTRACT: A study indicated that *Pealius homonoiae* Jesudasan and David and *Massilieurodes splendens* (Regu and David) are same species and a new name combination *Massilieurodes homonoiae* (Jesudasan and David) is proposed. Further, *Massilieurodes splendens* (Regu and David) is proposed as a new synonym of *Massilieurodes homonoiae* (Jesudasan and David).

KEYWORDS: *Massilieurodes homonoiae*, new combination

During the course of study of whiteflies of Indian subcontinent the authors came across a species of *Massilieurodes* from *Homonoia riparia* (Euphorbiaceae). Earlier records show that (Jesudasan and David, 1991) described *Pealius homonoiae* from *Homonoia riparia*. In 1992, Regu and David described *Dialeurodes* (*Gigaleurodes*) *splendens*, the host being *Homonoia riparia*. Jensen (2001) placed this species under *Massilieurodes* and proposed a new combination. A critical study of the holotype of the both the species available with B. V. David indicated that both are identical and fit well with the generic characters of *Massilieurodes* and a new name combination *Massilieurodes homonoiae* (Jesudasan and David) is proposed. Further, *Massilieurodes splendens* (Regu and David) is proposed as a new synonym of *Massilieurodes homonoiae* (Jesudasan and David).

Massilieurodes homonoiae (Jesudasan and David) comb. nov.

Pealius homonoiae Jesudasan and David. 1991. *Oriental Insects*, **25**: 318–320.
Dialeurodes (Gigaleurodes) splendens Regu and David. 1992. *J. Bombay Nat. Hist. Soc.*, **89**: 82–87.

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Massilieurodes splendens (Regu and David), Jensen., 2001. *Systematic Entomology*, **26**: 279–310. syn. n.

Materials examined: Holotypes:

1. *Pealius homonoiae* on *Homonoia riparia*, Walayar, 24.iii.1972, B. V. David; 2. *Dialeurodes* (*Gigaleurodes*) *splendens* on *Homonoia riparia*, Rajapalayam, 11.vi.1989, K. Regu; 10 pupal cases, on unidentified plant, Lakshadweep, 3.v.1997, K. Regu.

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Chemical nature of female accessory reproductive gland secretions in *Opisina arenosella* Walker (Lepidoptera: Cryptophasidae)

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ABSTRACT: *Opisina arenosella* has three accessory glandular organs associated with female reproductive system. The secretion in the bursa copulatrix contains lipids, glycogenous polysaccharides and proteins. Spermathecal gland secretion contains glycogenous polysaccharides and proteins only. Colleterial glands secrete proteins and glycogenous polysaccharides complexed with lipid. The chemical nature of these secretions give evidence of their probable function in the reproductive process.

KEYWORDS: Female accessory reproductive organs, bursa copulatrix, spermatheca, colleterial glands, secretion

Proteins, lipids and proteolytic enzymes have been reported from the bursa of insects (Davey, 1965; Bhosale *et al.*, 1987; Osanai, 1987). Spermatheca which stores the sperms, often have glandular areas which supply nutrients to the sperms stored in them. Spermathecal gland secretions are usually rich in glycogenous polysaccharides and proteins (Davey and Webster, 1967; Joshi, 1976; Bhosale *et al.*, 1987). Colleterial gland secretions either coat the eggs, provide sticky cements or form oothecae. In Dictyoptera and Orthoptera, colleterial gland secretions contain proteins and phenolic compounds (Hackman and Goldberg, 1960; Whitehead *et al.*, 1965a,b; Ghosh *et al.*, 1998). Proteins and lipids are reported from the colleterial gland secretions of Lepidoptera (Salkeld and Potter, 1953; Beament and Lal, 1957). The present paper reports the results of histochemical characterisation of the secretions in the bursa, spermathecal gland and colleterial gland of *Opisina arenosella*, a serious pest of cocount palm.

The bursa copulatrix, spermatheca and colleterial glands from newly emerged adult females were used for the present study. Histochemical procedures, as outlined in Pearse (1968) were followed. For localisation of proteins, the tissues were fixed in Carnoy's fluid. Sections were stained as per Bonhag's mercury bromophenol blue

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method. Control sections were treated in 3% trypsin solution for half an hour and washed before keeping in stain. For localisation of glycogen, Carnoy's fixed tissues were used. Sections were stained as per McManus Periodic Acid Schiff method. Control procedures were carried out by treating sections in acetic acid solution for 12 hours before oxidation in Periodic Acid. For lipids, tissues were fixed in Baker's formaldehyde calcium and sections stained in saturated Sudan Black B at room temperature. In control procedures, tissues were subjected to pyridine extraction at 60 °C for 24 hours and treated in Pottassium dichromate calcium solution, before blocks were made.

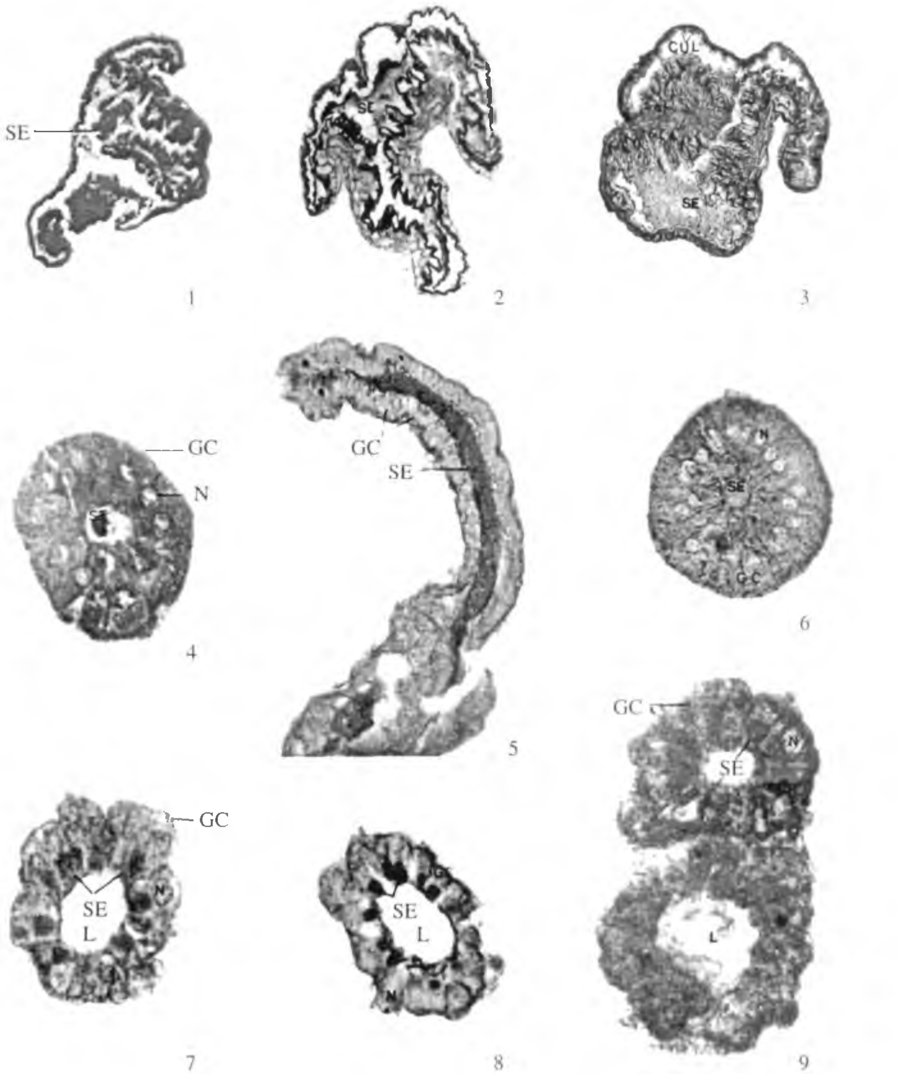
The secretion in the lumen as well as the cytoplasm of the glandular cells of corpus bursae, stain deeply with mercury bromophenol blue indicating the presence of proteins in the bursal secretion (Fig. 1). The secretion in the lumen is strongly PAS positive showing abundance of glycogenous polysaccharides (Fig. 2). When stained for lipids, with Sudan black, deeply stained granules were seen interspersed with weakly stained granules (Fig. 3). The staining characteristics indicate the presence of proteins, glycogenous polysaccharides and lipids in the bursal secretion of *Opisina*.

Spermathecal gland secretion in the lumen as well as inside the cells, stain deeply with mercury bromophenol blue (Fig. 4) as well as with PAS method (Fig. 5). However, the secretion is not at all stained with Sudan black (Fig. 6). These staining properties indicate the presence of proteins and glycogenous polysaccharides in the spermathecal gland secretion. Lipids are totally absent.

In the colleterial gland and in the reservoir, secretion is first collcted in vesicles towards the luminal part of the glandular cells before being discharged into the gland lumen. These vesicles are intensely stained with mercury bromophenol blue (Fig. 7), PAS (Fig. 8) as well as Sudan black (Fig. 9). But the secretion in the reservoir lumen is negative to bromophenol blue and PAS, while is intensely stained with Sudan black. It is probable that the glycogen and protein components of the secretion are subjected to some final processing in the cellular vesicles before they are released into the lumen. It is also probable that free protein and glycogen moieties capable of taking up bromophenol blue and Schiff's reagent respectively are absent in the secretion in the lumen of the gland and reservoir.

The secretion in the bursa copulatrix of *Opisina arenosella* contains lipids, proteins and glycogenous polysaccharides. Glycogen and lipids have been localised in the bursa of *Danaus plexippus* (Rogers and Wells, 1984) while Bhosale *et al.* (1987) reports the presence of proteins and glycogen in the bursa of *Bombyx*. The lipids and glycogen are thought to provide energy for mating and egg laying. The bursa of many insects which receive a spermatophore rich in proteins contain proteolytic enzymes for digesting the spermatophore (Osanai, 1987). The spermatophore in *Opisina* transfers proteins to the female during mating (Santhosh Babu, 1989). A proteolytic enzyme has also been detected in the bursa of mated females of *Opisina* (Geetha, 1991).

The spermathecal gland secretion in *Opisina* contains proteins and glycogen while lipids are totally absent. The glandular areas associated with spermatheca produce secretion that are considered to be of nutritive value to the sperms stored



FIGURES 1–9: 1. Cross section of Corpus bursae, fixative Carnoy's fluid; Mercury bromophenol blue × 250. 2. Cross section of Corpus bursae—Fixative Carnoy's fluid; periodic acid Schiff × 1000. 3. Cross section of Corpus bursae—Fixative Baker's formaldehyde calcium; Sudan Black B × 1000. 4. Cross section of spermathecal gland—Fixative Carnoy's fluid; Mercury bromophenol blue × 1000. 5. Longitudinal section of spermathecal gland—Fixative Carnoy's fluid; periodic acid Schiff × 1000. 6. Cross section of spermathecal gland. Fixative Baker's formaldehyde calcium; Sudan Black B × 1000. 7. Cross section of proximal part of tubular gland of colleterial gland—Fixative Carnoy's fluid; Mercury bromophenol blue × 1000. 8. Cross section of proximal part of tubular gland of colleterial gland—Fixative Carnoy's fluid; periodic acid Schiff method × 1000. 9. Cross section of proximal part of tubular gland of colleterial gland. Fixative Baker's formaldehyde calcium × 1000.

in them (Davey, 1965). The secretion in the lumen of spermatheca is a mucoprotein or glycoprotein in *Rhodnius prolixus* (Davey and Webster, 1967). In *Odontopus nigricornis* the secretion contains protein—polysaccharide moiety (Joshi, 1976). In *B. mori* (Bhosale *et al.*, 1987) proteinaceous secretions are reported. In *B mori* glycogen also is present. The chemical nature of spermathecal secretion in *Opisina* also suggests that it is of nutritive value to the sperms. This is supported by the observation that spermathecal proteins show a decline in mated females of *Opisina* compared to virgins of the same age (Geetha, 2002).

The colleterial glands in insects produce secretions that glues the eggs to the substratum, jelly like substance in which eggs of Trichoptera and Diptera are embedded and the material with which the ootheca of Orthoptera and Dictyoptera are formed (Hinton, 1981). In *Blatta orientalis*, the large left gland secretes a structural protein, a β-glucoside of an alcohol or an acid and a phenol oxidase, whereas the smaller right gland secretes a β-glucosidase. The acid or alcohol is then oxidised to the corresponding quinone by the phenol oxidase and the quinone crosslinks the structural proteins to form the ootheca in *Periplaneta americana* (Whitehead *et al.*, 1965a and b). Kawaski and Yago (1984a and 1984b) have identified glucosides in *Hierodula patellifera* and *Tenodera aridifolia*. Proteins have been reported in the colleterial gland secretions of *Mantis religiosa* (Rudall, 1956), *Nauphoeta cinerea* (Adiyodi, 1968) and *Bombyx mori* (Bhosale *et al.*, 1987). The colleterial gland cement in Lepidoptera include proteins and lipids in *Pieris brassica* (Beament and Lal, 1957). Lipids have been found in the colleterial gland secretion of *Diataraxia oleracea* (Salkeld and Potter, 1953). The colleterial gland secretion in *Opisina* also shows a dominance of lipid component in the present study. This secretion coats the eggs as they pass down through the vagina and helps to cement the eggs to the coconut leaves on which they are laid.

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Report of a new species of the Genus *Chionaema* Herr-Schäffer (Lithosiinae: Arctiidae: Lepidoptera) from India

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ABSTRACT: A new species *hampsoni* under genus *Chionaema* has been described and illustrated. This species is closely allied to *signa* Walker as far as general ground colour, ornamentation of collar, tegula, wing venation and trilobate costal tuft on the forewing are concerned. However, the new species can be easily distinguished on the basis of prominent antemedial and postmedial scarlet bands on forewing and its distinct genitalic structures such as male genitalia with uncus having pointed tip, aedeagus with smooth walls, vesica with densely packed large patches of cornuti and female genitalia with globular corpus bursae, signum missing.

KEYWORDS: *Chionaema*, species and genitalia

INTRODUCTION

While undertaking surveys in North-East India for the arctiid moths, as many as six representatives of a lithosiin species referable to genus *Chionaema* Herr-Schäffer have been collected from Arunachal Pradesh. The identity of this species could not be arrived at either from the relevant literature (Hampson, 1894, 1900) or from material available at National museums as well as from The Natural History Museum, London. Detailed morphological studies involving the examination of male and female genitalic structures have revealed that although congeneric, this new species is distinct from all other known species of genus *Chionaema* on the basis of its unique features. To examine genitalic features, the male and female genitalia have been dissected out. For doing so, the entire abdomen was detached from insect body, as cutting of last few segments often damages the constituent parts of male and female genitalia (Robinson, 1976). The terminology for naming various constitutent parts has been followed after (Klots, 1970). Description of this species is given below:

Genus *Chionaema* Herr-Schäffer

Herr-Schäffer, 1850, Aussereus, Scchmoot, 1850: 20.
Type species: *Chionaema puella* Drury.

***Chionaema hampsoni* n.sp.**

Head with vertex and frons furnished with white scales. Antenna simple, ciliated; scape studded with white scales; flagellum covered with brown and white scales. Eyes black with golden brown lining. Labial palpus slightly upturned, just reaching the lower levels of frons; first and second segments decorated with black scales, underside densely clothed with white scales; third segment with black scales.

Thorax and collar covered with white scales, the latter edged with scarlet; tegula furnished with white scales, striped with scarlet; scarlet spots present on meso and meta-thoracic segments. Forewing with ground colour white; a subbasal scarlet band, not reaching inner margin; costal edge scarlet to antemedial band; an antemedial scarlet band excurved obliquely below costa; a black spot in the cell, a discoidal black bar; an oblique postmedial scarlet band interrupted by a black spot, situated just below costa; costal tuft trilobate, two lobes decorated with white and scarlet, third one with black scales; whereas in female, postmedial band complete, slightly excurved below costa, then bent inwards and again excurved obliquely, no black spot beyond postmedial band, in place of discoidal bar two discoidal black spots present; vein R_2 arising from just before upper angle; R_3–R_5 stalked from angle, M_1 orginating from upper angle; M_2 usually from above lower angle, absent in male; M_3 from angle of cell; Cu_1 from before lower angle of cell. Hindwing with ground colour snow white; vein $Sc + R_1$ arising beyond middle of cell; RS and M_1 well stalked from upper angle of cell; M_3 and Cu_1 stalked from lower angle of cell. Legs dressed with white scales; fore and mid tibiae and tarsi banded with black; outer tibial spurs half the length of inner ones.

Abdomen densely clothed with white scales.

Male genitalia

Uncus small, slightly curved, broad in the middle, tip rounded dorsally setosed; tegumen long, highly developed; vinculum half the length of tegumen, well sclerotized; saccus broad, U-shaped, inner wall slightly produced. Valva long, sacculus and costa marked; cucullus of uniform width, ending well above valvula, tip rounded; valvula with its distal end bearing a sharp pointed spine; juxta large, shield-like. Aedeagus with both of its walls equally sclerotized; vesica bearing a scobinate patch anteriorly and two patches of densely packed cornuti in distal half.

Female genitalia

Corpus bursae round and membranous; signum absent; ductus bursae broad anteriorly and heavily sclerotized, narrow and membranous posteriorly; accessory sac present; both pairs of apophyses narrow, with their apices pointed; anterior apophyses half and length of posterior ones; papilla analis triangular, fringed with fine setae.

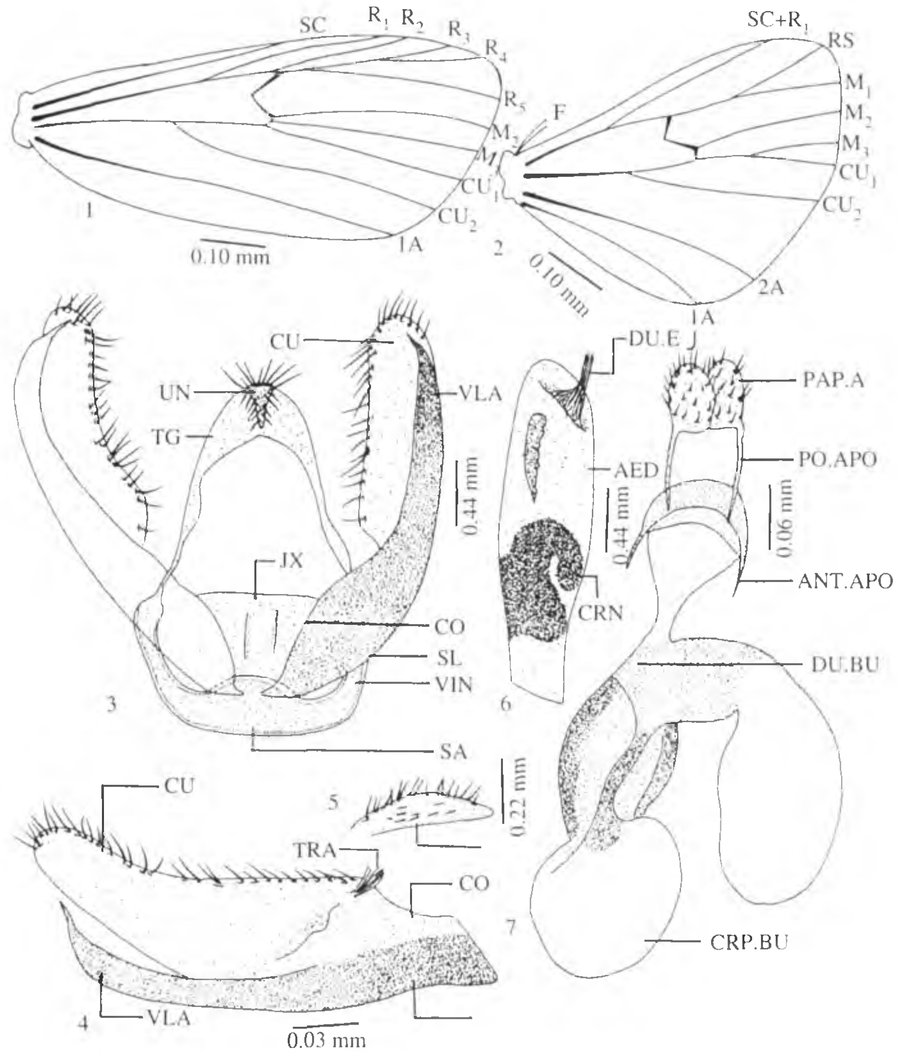

FIGURE 1–7: FIG. A. Adult of *Chionaema hampsoni* n.sp.; FIG. 1. Forewing of *Chionaema hampsoni* n.sp.; FIG. 2. Hindwing of *Chionaema hampsoni* n.sp.; FIGS. 3–6. Male genitalia of *Chionaema hampsoni* n.sp.; FIG. 7. Male genitalia of *Chionaema hampsoni* n.sp.;

Wing expanse (half)	:	Male : 20 mm.
	:	Female : 22 mm.
Holotype	:	Arunachal Pradesh: West Kameng District, Bomdila, 2430 m ASL, 10.ix.1994, 1♂.
Allotype	:	Arunachal Pradesh: West Kameng District, Bomdila, 11.ix.1994, 1♀.
Paratype	:	Arunachal Pradesh: West Kameng District, Bomdila, 10.ix.1994, 2♂♂; Dirang, 12 ix. 1994, 1♂, 1♀.

REMARKS

The new species reported herein completely conforms to the characterization of genus *Chionaema* Herr. Schäffer and is closely allied to *C. signa* Walker, so far as the ornamentation of head, labial palpi, legs and presence of trilobate costal tuft on forewing are concerned. However, it differs from *signa* with respect to several other characters such as forewing with vein Cu_1 arising from before lower angle of cell, whereas in *signa* it originates from lower angle of cell and forewing with prominent bands in new species. Also in this species, uncus in the male genitalia have a pointed tip, valvula with pointed tip, aedeagus with both of its walls smooth, vesica with three patches of densely packed cornuti whereas in *signa*, valvula with spined-like tip, aedeagus with small denticles near distal end, vesica with small patches. The female genitalia have globular corpus bursae and signum absent in the new species whereas signum is present in *signa*.

Etymology:

This species has been named after the name of great Lepidopterist and eminent worker of family Arctiidae, G. F. Hampson.

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Abbreviations

1A	:	First anal vein	PO.APO	:	Posterior apophyses
2A	:	Second anal vein	R_1	:	First radial vein
ACC.SC	:	Accessory sac	R_2	:	Second radial vein
AED	:	Aedeagus	R_3	:	Third radial vein
ANT.APO	:	Anterior apophyses	R_4	:	Fourth radial vein
CO	:	Costa	R_5	:	Fifth radial vein
CRN	:	Cornuti	RS	:	Radial sector
CRP.BU	:	Corpus bursae	SA	:	Saccus
Cu	:	Cucullus	Sc	:	Subcosta
Cu_1	:	First cubital vein	Sc+R	:	Subcosta and radial vein
Cu_2	:	Second cubital vein	SIG	:	Signum
DU.BU	:	Ductus bursae	SL	:	Sacculus
DU.EJ.	:	Ductus ejaculatoris	TG	:	Tegumen
G.P.	:	Genital plate	TRA	:	Transtilla
JX	:	Juxta	UN	:	Uncus
M_1	:	First medial vein	VES	:	Vesica
M_2	:	Second medial vein	VIN	:	Vinculum
PAP.A	:	Papilla analis	VLA	:	Valvula

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Biology and predation potential of *Canthecona furcellata* Wolff. (Hemiptera: Pentatomidae) on *Notolophus antiqua* Linn. a pest of primary tasar food plants

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ABSTRACT: *Canthecona furcellata* (Wolff.) is predaceous on larvae of *Notolophus antiqua* Linn. a defoliator of primary tasar food plants. Biology and predation potential of the predator on an alternate host, *N. antiqua* was studied. The bug, which is multi-voltine in nature, took 49.6 days to complete its life cycle. The total predation potential of different nymphal instars and adult was found to be 23.4 and 72.6 number of third instar larvae respectively. The fecundity of bug was found to be 52.2 eggs. Variation in site of piercing of proboscis was observed to be instar-specific.

KEYWORDS: *Canthecona furcellata*, *Notolophus antiqua*, *Antheraea mylitta*, tasar food plants

Notolophus antiqua. Linn. (Lepidoptera: Lymantriidae), commonly known as vapourer tussock moth, is a major pest of primary tasar food plants, *Terminalia arjuna* Beddl. and *T. tomentosa* W&A and causes considerable damage to the foliage. The young larvae nibble on the leaf surface while older larvae consume the whole leaf (Singh and Thangavelu, 1992). Singh *et al.* (1990) reported large-scale defoliation of primary tasar food plants by *N. antiqua* at Central Tasar Research and Training Institute, Ranchi field during August–September 1989 and quantified the foliage damage to the extent of 80–90%. The rearing of tasar silkworm being out-doored is open to the attack of various parasites and predators inflicting a crop loss of 40–50% (Sen and Jolly, 1967). The predatory habit of stink bug, *Canthecona furcellata* on several pests of agricultural crop in south-eastern Asia was recognised by Cherian (1917), and as a predator of tasar silkworm it was first reported by Distant (1902) and later by Jolly (1967). Pentatomid bug, *C. furcellata* is found to cause damage to the larvae of tasar silkworm from July to November and also found to feed on the

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TABLE 1. Biological parameters of *C. furcellata* reared on *N. antiqua*

Parameters	Duration (days) ± SD
Pre-oviposition period	6.6 ± 0.5
Oviposition	11.5 ± 1.3
Post-oviposition period	10.7 ± 1.3
Fecundity	52.2 ± 5.7
Incubation period	6.3 ± 1.5
I instar nymph	3.3 ± 0.3
II instar nymph	3.1 ± 0.4
III instar nymph	2.9 ± 0.4
IV instar nymph	4.2 ± 0.4
V instar nymph	5.5 ± 0.4
Total nymphal period	19.0 ± 0.8
Adult longevity (Male)	21.6 ± 1.1
Adult longevity (Female)	27.0 ± 1.6

larvae of *N. antiqua* as an alternative host (Sen and Jolly, 1967; Sen *et al.*, 1971). The life cycle and developmental morphology of *Canthecona furcellata* was studied on *Antheraea mylitta* D. (Lepidoptera: Saturniidae) (Sen *et al.*, 1971). We studied the biology and predation potential of *C. furcellata* on *N. antiqua*, an alternative host, in order to work out a strategy for control of *C. furcellata* in the rearing field.

The biology of the predator was studied during August–October in laboratory conditions (average maximum temperature 26.80 °C, average minimum temperature 19.19 °C and relative humidity 81.83%). The adults of predatory bug were collected from the rearing field and reared in the laboratory following methods of Yeargan (1982) to obtain eggs of the predator. The adult male and female were kept in plastic containers (10 cm diameter and 20 cm in height) and fed with third instar larvae of *N. antiqua*. For studying the predation potential, 10 newly hatched nymphs were placed in separate plastic containers with release of 20 third instar larvae of *N. antiqua* and a twig of *T. arjuna* containing 8–10 leaves for food and also for shelter to the nymphs in each container. These nymphs were maintained in the containers till the adulthood. Observations on pre-oviposition, oviposition, post oviposition period (life span of female after oviposition), fecundity, incubation period, nymphal and adult longevity were recorded (Table 1). Observations on predation potential of different nymphal instars and adult of *C. fucellata* on third instar larvae of *N. antiqua* were also recorded to determine the potential of predatory bug (Table 2). Fifteen replications were maintained for this study.

Observation on the mating behaviour of *C. furcellata* reveals that the adults copulate on fourth and fifth day after the last nymphal moult. The mating took place on the leaves of the food plants in daytime and continues for about 8–10 hrs. In the act of copulation the couples may remain in flight or alight on plant. The pre-oviposition

TABLE 2. Predation potential of *C. furcellata* on third instar larvae of *N. antiqua*.

Stages of *C. furcellata*	Mean number of larvae predated ± SD
I instar	Predating not observed
II instar	3.4 ± 0.5
III instar	5.6 ± 1.1
IV instar	7.4 ± 1.1
V instar	7.0 ± 0.7
Adult Male	67.6 ± 4.8
Adult Female	77.6 ± 2.7

and oviposition period varied from 6–7 and 11–12 days respectively. The eggs were laid in batches arranged in 3–6 rows. Each batch consists of 45–60 eggs.

Each female lays about 240–260 eggs and hatching percentage varied from 90–95%. Singh *et al.* (1989) reported 15–28 eggs per batch with the fecundity varying from 38 to 42 eggs. The post oviposition period varied from 10–12 days and after which female died. Incubation period lasted for 6–7 days. Kapoor *et al.* (1973) has reported incubation period of 5–7 days in September–October, which is in agreement with the present findings, while, Singh *et al.* (1989) reported incubation period of 6–14 days in October–December. Atmospheric temperature is the main contributing factor in variation of incubation of eggs. There were five nymphal instars, which lasted for 19.0 days. Singh *et al.* (1989) reported that nymphal period varied from 17–20 days. The first instar nymph survives by sucking the leaf sap and not by predation while the second, third, fourth and fifth instars nymph by predation of 3.4, 5.6, 7.4, 7.0 number of third instar larvae of *N. antiqua* respectively. The observations also reveal that unlike nymphal stage the adult shows marked sexual dimorphism (Sen *et al.*, 1971). The adult longevity of male and female was recorded to be 21.6 days and 27.0 days respectively. The observations on mating, egg laying and hatching indicates that the predator is multi-voltine in nature having five generations in a year (Sen *et al.*, 1971). The total predation potential of male and female were recorded as 67.6 and 77.6 number of third instar larvae of *N. antiqua* respectively. Sen *et al.* (1971) reported that 131–221 first to third instars larvae of *A. mylitta* were predated by an individual bug, while predation decreases abruptly with the advance of age of host larvae. Single adult took 30, 70, 90, 120, and 180 minutes in predation of first, second, third, fourth and fifth instars larvae of *N. antiqua* respectively. The predation potential of adult of *C. furcellata* was found to be only one full grown larva within 24 hours while 5–6 numbes of first instar larvae were fed by predation during the same hours. Variation in site of piercing of proboscis was instar specific. In the first, second and third instar larvae of *N. antiqua*, the adult bug pierced its proboscis almost in the middle of the body in such a way that the host larva does not escape from the bug control, while in fourth and fifth instars the bug pierced either in prothorax or in last abdominal segments (Bhadauria *et al.*, 1989).

The bug was found to kill the early instars larvae in one prick while in later instars it requires more than one prick.

Based upon the finding, it may be concluded that *C. furcellata* is beneficial to tasar culture. It serves as a bio-control agent against larvae of *N. antiqua*. Paradoxically, *C. furcellata* is a predator of early instar larvae of *A. mylitta*. Therefore, it is suggested to have further studies to work out management strategies for *C. furcellata* wherein, the predation of early instar larvae of *A. mylitta* could be avoided.

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Antifeedant activity of *Annona squamosa* Linn. against *Crypsiptya coclesalis* Walker (Lepidoptera: Pyralidae)

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ABSTRACT: Antifeedant activity of *Annona squamosa* leaves against *Crypsiptya coclesalis* was investigated in laboratory. Petroleum ether and hexane fractions proved best, with over 90% leaf protection. It was followed by benzene, acetone and chloroform. Methanol fraction was least effective. Petroleum ether fraction was tested in concentrations ranging from 0.05 to 0.8%. Lowest concentration of 0.05% also gave 96% protection to the leaves. Field stability of *A. squamosa* leaves extracted directly in methanol was also evaluated in field cum lab experiment, and compared with commercially available neem product Amrutguard®. Methanolic extract proved to be at par with Amrutguard® and could provide 57% leaf protection upto one week.

KEYWORDS: Antifeedant activity, *Annona squamosa*, bamboo leaf roller, *Crypsiptya coclesalis*, field persistence

Bamboo leaf roller, *Crypsiptya coclesalis* Walk., is a major pest of bamboos especially of *Dendrocalamus strictus*. During severe infestations, it causes considerable losses (Beeson, 1941; Browne, 1968). Despite its economic importance, reports on its control measures using natural compounds and natural enemies have been very meagre (Chatterjee and Misra, 1974; Vastrad, 1994; Kak and Khan, 1999; Kulkarni, 2001).

Custard apple, *Annona squamosa* Linn., besides being economically important has also been reported to possess insecticidal and repellent properties against several insect pests including forest pests (Kulkarni, 2001). In this paper the antifeedant activity of *A. squamosa* against larvae of *C. coclesalis* Walker, is reported.

Larvae of *C. coclesalis* were collected from bamboo nursery and plantation at the campus of Tropical Forest Research Institute, Jabalpur, India. The larvae were

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kept in glass beakers covered with muslin cloth and reared on fresh leaves in the laboratory. On emergence, the adults were released into wooden cages containing bamboo seedlings for oviposition. The newly moulted 5th instar larvae were separated and starved for at least 6 hr prior to bioassay.

Leaves of *A. squamosa* were collected, shade dried and converted into powder. The powdered material (50 g) was subjected to extraction using Soxhlet's apparatus sequentially in petroleum ether, hexane, benzene, chloroform, acetone and lastly in methanol. After evaporation of solvents, residues were dissolved in respective solvents to obtain 2% stock solutions. Each residue represented active compounds or fraction soluble in the respective solvent. Different dilutions were prepared in water using the above stock solution by adding a few drops of Triton X-100 as emulsifier. For assessment of field stability/persistence, powdered material was extracted directly in methanol and after obtaining the dried residue in the manner discussed above, it was diluted to the desired concentrations.

Measured leaf area of freshly collected *D. strictus* leaves were treated with 0.5% concentration of all the solvent fractions, allowed to dry and then exposed for feeding to single larva in no-choice conditions for 48 hr in a petri-dish, 10 cm diam. It was repeated in 5 replications. One set was treated with solvent as control. Feeding in all cases was observed by measuring leaf area with the help of laser leaf area meter (Model CI-203, CID Inc., USA). Leaf area consumption and per cent antifeedancy were calculated following the method of Kulkarni and Joshi (1998). To investigate best effective concentration, different concentrations of petroleum ether extract ranging from 0.05 to 0.8%, were prepared and leaves treated. Treated leaves were then exposed to the larvae in the same manner described above.

To test the persistence of deterrence effect under field conditions, a field and laboratory trial was laid out. Methanolic leaf extracts at concentrations 0.5, 1 and 2% were sprayed using a spray pump on *D. strictus* seedlings in nursery. For comparing the results, commercially available neem product containing azadirachtin (Amrutguard®) was also used at similar concentrations. Each treatment was sprayed on 100 seedlings. Control seedlings were treated only with water. Each such set was replicated thrice and arranged in random blocks. Leaves from treated and control seedlings were randomly plucked after 0, 24, 72 and 168 hrs and subjected to feeding bioassays against starved early fifth instar larvae in laboratory. All the laboratory experiments were carried out at 28–30 °C and 80–90% RH.

Data obtained in per cent values were subjected to arc sin transformation, prior to statistical analysis. All the data were subjected to ANOVA using SX Statistical package (statistix, PC DOS Version 2.0, 1985, 1987, NH Analytical Software) with DMRT.

Petroleum ether, hexane, benzene and acetone fractions of *A. squamosa* leaves were equally effective as compared to control with percentage leaf protection of 95, 91, 88 and 84, respectively, followed closely by chloroform with 72%. Methanol fraction gave only 18% protection (Table 1). Petroleum ether fraction of *A. squamosa* at concentration ranging from 0.05, 0.1, 0.3, 0.5 and 0.8 per cent gave 96, 93, 99, 99.49

TABLE 1. Antifeedant activity of sequential fractions of *A. squamosa* leaves in different solvents against *C. coclesalis*

Solvent fraction (0.5% concentration)	Leaf protection over control (%)
Petroleum ether	95.43 (82.10)^{a}
Hexane	91.50 (79.12)^{a}
Benzene	88.21 (71.99)^{ab}
Chloroform	72.89 (59.30)^{b}
Acetone	84.17 (66.84)^{ab}
Methanol	18.07 (15.30)^{c}
Control	0.00^{c}

Figures in parentheses are arc sin transformed values of percentages.
Means with same letters are not significantly different under DMRT.

and 98% leaf protection over control; within the treatments the means were statistically similar.

Leaf area protection (over control) when treated leaves were collected at different intervals and exposed to larvae is shown in Table 2. When treated leaves were exposed to larvae just after spraying (0 day), methanolic leaf extract at and above 1% was found effective and at par with the neem based commercial product Amrutguard® ($p < 0.05$) at similar concentration. Maximum protection (79%) was obtained at 2% concentration of *A. squamosa* methanolic extract. Methanolic extract of *A. squamosa* and Amrutguard® at 1 and 2% were statistically equal ($p < 0.05$). The lowest concentrations 0.5% also prevented feeding compared to control. Though per cent protection exhibited by the treated leaves continued to reduce in subsequent days, it showed similar trends with respect to treatments after 24 and 72 hr. After 168 hr maximum protection by 2% *A. squamosa* extract remained 57% over feeding in control. It was still at par with 1 and 2% Amrutguard® ($p < 0.05$).

It is apparent that petroleum ether, hexane, benzene, acetone and chloroform fractions of *A. squamosa* leaves, possessing oils, fatty acids and different secondary compounds; alkaloids and terpenoids, exhibit antifeedant activity. They give 84 to 95% leaf protein against the *C. coclesalis* and could be used as a protectant in nursery against this pest to minimize the use of chemical insecticides.

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TABLE 2. Persistence of methanolic extract of *A. squamosa* leaves and Amrutguard on bamboo seedlings under field condition

Treatment (%)	Leaf area protection over control (%) of samples collected at different intervals after spraying (hr) against *Cryposiptya coclesalis*			
	0	**24**	**72**	**168**
A. squamosa 0.5	50.68 (45.21)^{c}	38.34 (36.02)^{bc}	16.08 (21.64)^{c}	24.90 (28.51)^{cd}
A. squamosa 1.0	68.81 (56.72)^{ab}	68.90 (59.17)^{a}	59.51 (50.92)^{a}	41.37 (37.93)^{bc}
A. squamosa 2.0	79.39 (63.59)^{a}	67.78 (57.98)^{ab}	65.04 (55.77)^{a}	57.66 (49.51)^{a}
Amrutguard 0.5	57.42 (49.33)^{bc}	32.42 (28.96)^{c}	38.98 (35.01)^{b}	15.65 (19.07)^{d}
Amrutguard 1.0	75.75 (62.26)^{a}	78.63 (65.28)^{a}	70.31 (57.48)^{a}	49.16 (44.49)^{ab}
Amrutguard 2.0	69.24 (58.67)^{ab}	73.06 (61.31)^{a}	68.29 (55.99)^{a}	46.11 (42.65)^{ab}
Control	0.0^{d}	0.0^{d}	0.0^{d}	0.0^{e}

Means with same letters are not significantly different under DMRT.

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